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CREEL SURVEYS CONDUCTED IN INTERIOR ALASKA DURING 1989[1]

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ABSTRACT

Creel surveys were conducted on seven of the major fisheries within the Tanana River drainage. These fisheries included (1) Chatanika River whitefish *Coregonus pidschian*, *Coregonus sardinella*, *Prosopium cylindraceum* spear fishery, (2) upper Chena River Arctic grayling *Thymallus arcticus* fishery, (3) lower Chena River chinook salmon *Oncorhynchus tshawytscha* fishery, (4) Delta Clearwater River Arctic grayling fishery, (5) Piledriver Slough rainbow trout *Oncorhynchus mykiss* and Arctic grayling fishery, (6) Salcha River chinook salmon *Oncorhynchus keta* fishery, and (7) Harding Lake Arctic char *Salvelinus alpinus* fishery. In addition, information on the northern pike *Esox lucius* fishery at Harding Lake was obtained. Angler effort, catch-per-unit-effort, harvest-per-unit-effort, catch, and harvest were estimated for five of these fisheries. Catch-per-unit-effort and harvest-per-unit-effort were estimated for two fisheries. Age and length compositions, were estimated for five fisheries. Angler demographics and angler opinions concerning the fisheries and their management were recorded for all fisheries.

At the Chatanika River fishery, estimated harvest of whitefish was 16,068 (standard error = 1,611) and harvest-per-unit-effort was 2.50 (standard error = 0.28). At the upper Chena River fishery, estimated harvest of Arctic grayling was 3,325 (standard error = 1,455) and harvest-per-unit-effort was 0.21 (standard error = 0.07). At the lower Chena River and Salcha River fisheries, estimated harvest of chinook salmon was 685 (standard error = 224) and 123 (standard error = 43), respectively; harvest-per-unit-effort was 0.15 (standard error = 0.06) and 0.02 (standard error = 0.01), respectively. At the Delta Clearwater Arctic grayling fishery, the greatest harvest-per-unit-effort (1.59, standard error = 0.82) occurred in June. At the Piledriver Slough Arctic grayling and rainbow trout fisheries, the estimated harvest-per-unit-effort was 0.05 (standard error = 0.02) and 0.15 (standard error = 0.05), respectively. At the Harding Lake fishery, the estimated harvest of northern pike in the summer was 1,237 (standard error = 453), and of Arctic char in the winter was at least 200.

KEY WORDS: creel survey, catch, harvest, catch-per-unit-effort, harvest-per-unit-effort, angler effort, angler demographics, angler questionnaires, angler surveys, age composition, length composition, interior Alaska, Tanana River drainage.

INTRODUCTION

Background

The Arctic-Yukon-Kuskokwim (AYK) Region encompasses an area that covers almost two-thirds of the State of Alaska and includes all of Alaska north of Bristol Bay and the Alaska Range (Figure 1). Within this area, the state's largest river systems (Yukon, Kuskokwim, Colville, and Noatak) are found, along with thousands of lakes, and thousands of miles of streams. These waters support a large number of recreational fisheries for both freshwater and anadromous fish species that include Arctic cisco *Coregonus autumnalis*, Arctic char *Salvelinus alpinus*, Arctic grayling *Thymallus arcticus*, anadromous chinook salmon *Oncorhynchus tshawytscha*, anadromous and land-locked coho salmon *O. kisutch*, anadromous chum salmon *O. keta*, burbot *Lota lota*, Dolly Varden *S. malma*, humpback whitefish *C. pidschian*, lake trout *S. namaycush*, least cisco *C. sardinella*, northern pike *Esox lucius*, rainbow trout *O. mykiss*, round whitefish *Prosopium cylindraceum*, and sheefish *Stenodus leucichthys*.

For sport fishery management purposes, the AYK Region was divided into two areas, the Tanana River drainage (includes all waters within the Tanana River drainage), and the AYK area (includes all waters outside the Tanana River drainage; Figure 1). Even though the AYK Region encompasses a very large area, the majority (approximately 75 %) of the recreational angler-effort and harvest occurred near the major population centers (Fairbanks, Delta Junction, and Tok) within the Tanana River drainage (Figure 2).

From 1977 through 1982, harvest of all fish species increased about 19% annually to a peak of about 179,000 in the Tanana River drainage and approximately 275,000 in the AYK Region (Figure 2). From 1983 to 1987, harvest decreased in both the Tanana River drainage and AYK Region. The decrease in harvest that occurred 1983 was probably due to the overharvest of the major species in the Tanana River drainage and the subsequent decline of the major fish stocks. Because of this decline, restrictive management regulations were instituted for the major fisheries in the Tanana River drainage in 1987 and 1988. In spite of restrictive regulations, harvest and angler effort increased in 1988. The stocking program in interior Alaska contributed significantly to the sport fishery in 1988. About 50% of the fish harvested in the interior in 1988 had been stocked (ADFG 1990).

Monitoring of the Tanana River drainage recreational fisheries is important to evaluate the effectiveness of the stocking program, and to assess the consequences of newly-imposed restrictive regulations on indigenous stocks. Conservation of indigenous stocks is desired in interior Alaska, through use of restrictive regulations and by diverting fishing pressure to stocked species. One method of assessing the success of conservation efforts is through the use of creel surveys.

A comprehensive analysis of the creel survey that were conducted by the Alaska Department of Fish and Game (ADFG) in the AYK Region during 1989 is presented in this report. Many of the same sampling techniques and estimation procedures have been utilized for all the creel survey. However, there were also many techniques and procedures that were specific to each creel survey.

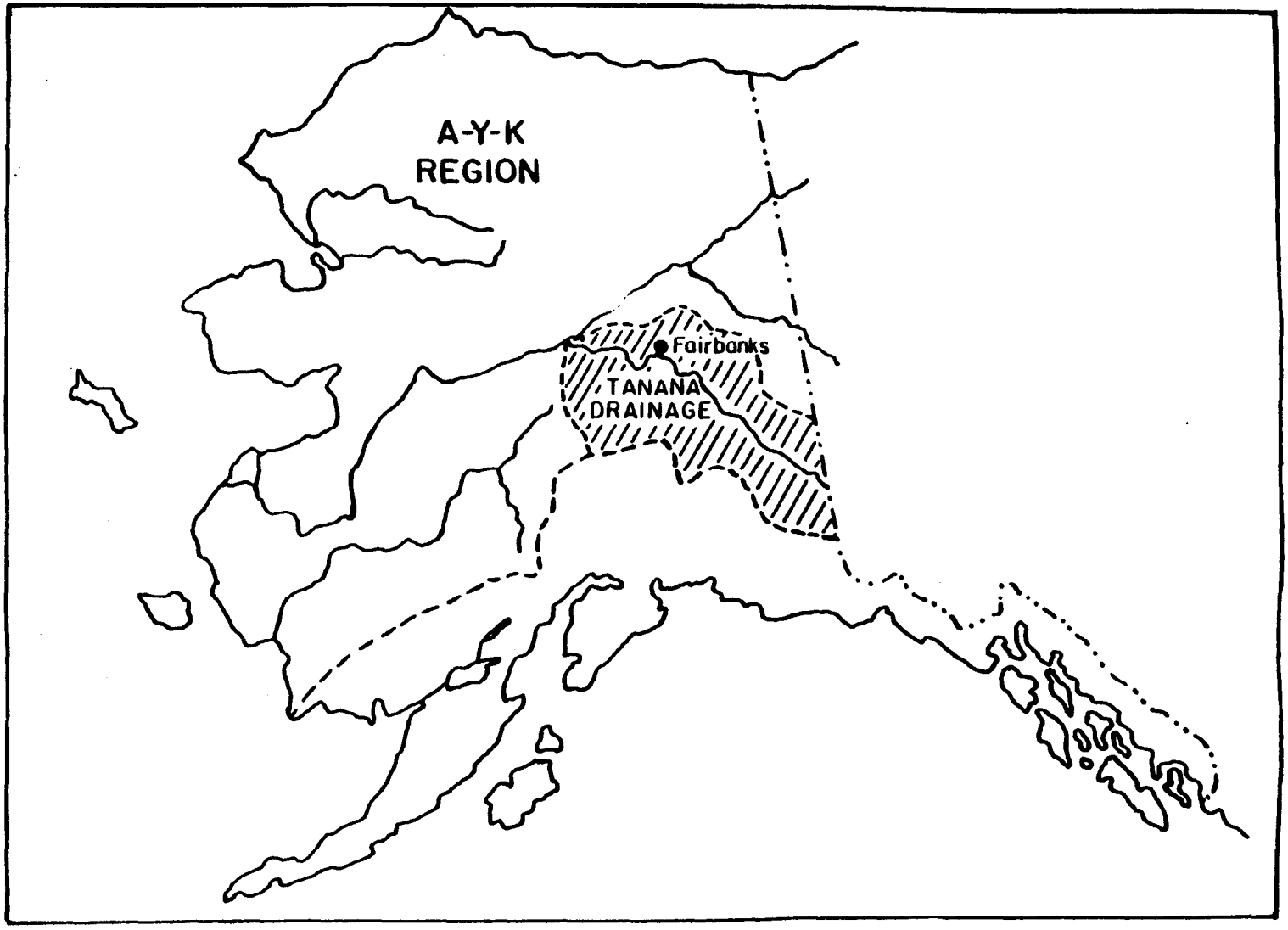

Figure 1. Map of Arctic-Yukon-Kuskokwim (AYK) Region and Tanana River drainage, Alaska.

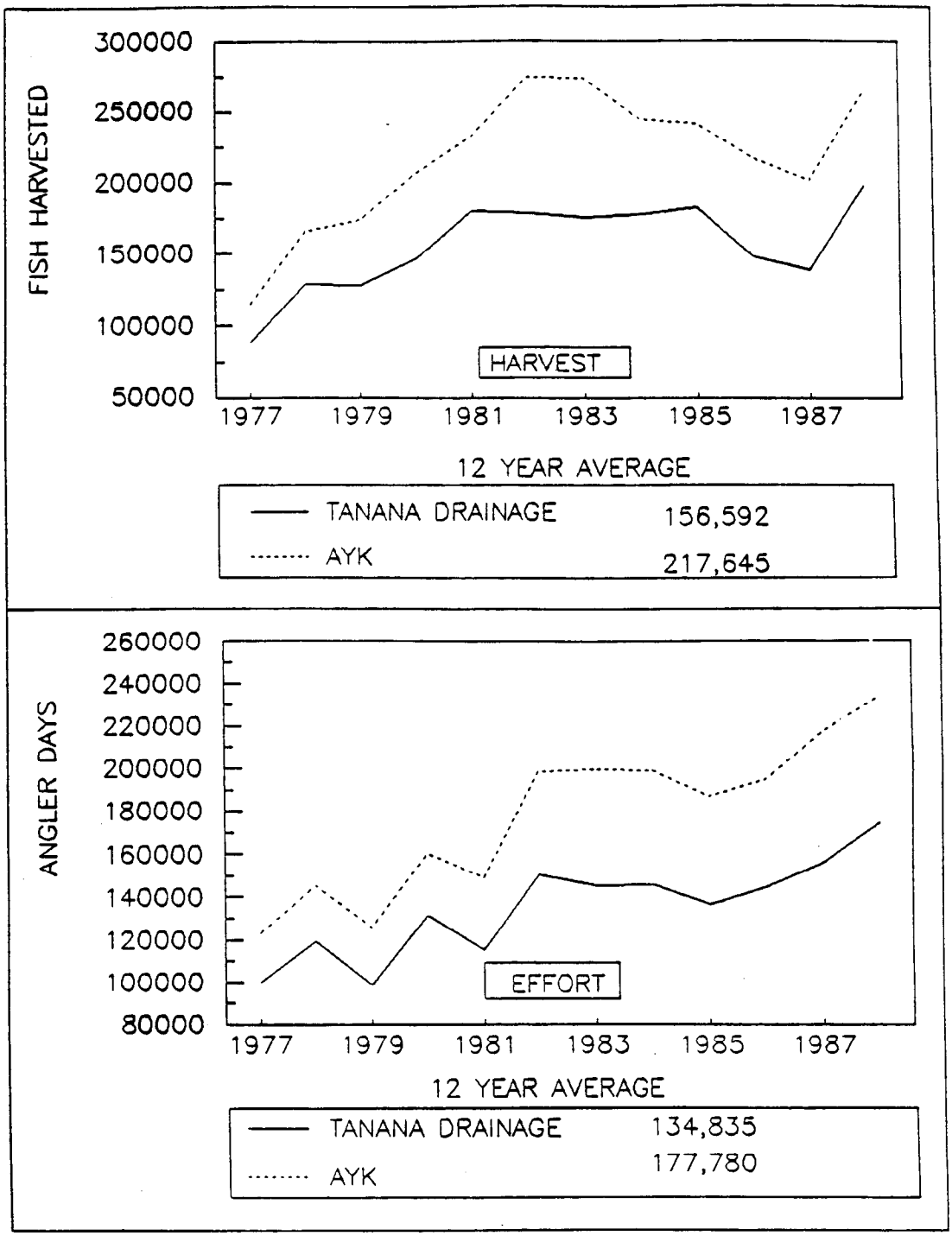

Figure 2. Effort and harvest by recreational anglers in the AYK Region (includes Tanana River drainage) and Tanana River drainage sport fish management areas, 1977-1988.

For this reason, a general methods section is first presented that includes the general sampling techniques and estimation procedures utilized during the creel survey. A separate chapter is then presented for each creel survey. Each chapter contains an introduction, methods, results, and discussion section that are specific to each creel survey.

Objectives of the Creel Survey Program

Creel surveys were conducted at seven of the major fisheries within the Tanana River drainage. The specific objectives of the creel surveys were to provide information concerning harvest, catch, angler-effort, catch-per-hour (CPUE), harvest-per-hour (HPUE), and biological data (i.e., length and age compositions of harvested fish). Additional information was obtained that included: catch distribution among user groups, temporal and spatial use patterns, angler characteristics (i.e., sex and residency), angler opinions concerning management of a fishery, sport fishery impacts on indigenous stocks, stocked fish contribution to a fishery, and the effectiveness of in-season management decisions.

The long term goals of the creel survey program are to: (1) develop historical data bases to allow monitoring of both the recreational fisheries and the exploited fish populations; (2) develop regulations that reflect the desires of the angling public while ensuring the sustained health of the resource; and (3) determine the effects of management regulations on the fisheries, fish populations, and recreational angling public.

METHODS

General Study Design

Two types of creel survey were conducted in the AYK Region in 1989 (Table 1). The first type was harvest surveys in which angler effort, catch, harvest, CPUE, and HPUE were estimated. The second type of creel survey was CPUE surveys, in which only CPUE and HPUE were estimated. Age and/or length data were collected at five fisheries; angler information was collected during all creel survey.

General Sampling Procedures

All creel surveys were based on a stratified random sampling design. The strata in each fishery were defined to maximize the relative precision of the estimates of angler-effort (i.e. levels of angler-effort are expected to be similar within a stratum) and were based upon historical creel survey data (when available). The number of angler counts collected in a given fishery was determined by the amount of technician time available each month and an estimate of the minimum number of samples needed to achieve the desired level of precision according to procedures described by Cochran (1977). Sampling effort was optimally or proportionally allocated based upon the number of anglers or amount of time in each stratum.

Table 1. Summary of information collected during creel surveys conducted in the interior of Alaska during 1989.

Fishery	Species[a]	Time Period	Type of Creel Survey	Number of Strata	Angler Types
Chatanika River	LC,HW	9 Sep - 16 Oct	Harvest	10	Shore
Chena River	GR	19 May - 13 Sep	Harvest	11	Shore
Lower Chena River	KS	7 Jul - 30 Jul	Harvest	8	Boat/Shore
Delta Clearwater River	GR	1 Jun - 27 Aug	CPUE	18	Boat/Shore
Piledriver Slough	RT,GR	4 May - 28 Aug	CPUE	16	Shore
Salcha River	KS	7 Jul - 30 Jul	Harvest	4	Boat/Shore
Harding Lake					
Summer	NP	2 Jun - 24 Aug	Harvest	7	Boat/Shore
Winter	AC	23 Dec - 24 Mar	CPUE	4	Shore

[a] HW = Humpback Whitefish
LC = Least Cisco
GR = Arctic Grayling
RT = Rainbow Trout
KS = Chinook Salmon
NP = Northern Pike
AC = Arctic Char

Angler-effort was only estimated for harvest surveys. Angler-effort was estimated from angler counts conducted at randomly selected time periods within a stratum. Both roving and/or stationary creel surveys were used depending upon the fishery. Roving creel surveys were used in fisheries with many access points and/or surveys that covered a large geographic area. Stationary creel surveys were used in fisheries with a single access point, and were generally comprised of exit interviews.

Angler interviews were conducted during both harvest and CPUE surveys. During harvest surveys, technician time was split between counting anglers and interviewing anglers. However, only angler interviews were conducted during CPUE surveys. Angler interviews were used to collect the following information: CPUE, HPUE, angler characteristics, and biological data from harvested fish.

The sampling schedule for a creel survey was developed by determining the number of sample periods in each stratum. Sample periods were defined as the time allocated to collect a sample. The sample periods were then numbered consecutively for an entire month. The periods to be sampled in each stratum were selected with the use of a random number table. Sample period numbers were drawn, without replacement, until the number of sample periods designated for that stratum had been selected. This procedure was completed independently for each stratum. The length of the sample period (hours needed to conduct angler count(s) and/or angler interview(s)) for each fishery was based on the type of count (roving or stationary) and the estimated time required to obtain a sufficient number of interviews (for stationary creel surveys) or to sufficiently cover the entire fishery area (roving creel surveys; Table 1). Multiple angler counts were conducted during some sampling periods. For multiple counts, a randomly selected time during each hour of the sample period was selected for an angler count.

General Data Collection

Only anglers actively fishing were counted during angler counts. For roving angler counts, the technician counted anglers while traveling from one end of the fishery to the other (the direction of travel for the angler count was determined at random). Stationary angler counts were made from a vantage point were the entire fishery could be seen.

Angler interviews were conducted for each individual angler contacted. The angler interviews were either complete- or incomplete-trip interviews. Complete-trip angler interviews were preferred. However, the majority of the angler interviews conducted during a roving creel survey occurred prior to the completion of the fishing trip. Almost all the interviews obtained during stationary creel survey were from anglers who had completed their fishing trip. All anglers present during a sample period were interviewed if possible.

During each interview, anglers were asked the following:

1) the length of time spent fishing;
2) the number of fish caught by species;

3) the number of fish caught and kept by species; and,
4) angler characteristics that include;
    a) male or female,
    b) youth or adult,
    c) resident or nonresident,
    d) local or nonlocal,
    e) tourist or military, and
    f) terminal fishing gear (spinner/bait/flies/jugs/trolling/spear).

In addition, anglers were asked several questions regarding management strategies and regulations. At all fisheries, the anglers were asked to rate the quality of fishing as either excellent, good, fair, or poor. In addition, specific questions about the fishery, and/or current or proposed management strategies and regulations were asked.

Biological data (i.e., fork length and age) were collected for Arctic grayling, rainbow trout, Arctic char, and other fish, except salmon and whitefish. Biological data for salmon and whitefish were collected during research studies conducted on these populations, because it was found that biological data collected during research did not differ from that in the harvest sample (Baker 1988). The fork length (tip of snout to fork of tail) was measured for all species. All length measurements were made to the nearest 1 millimeter. Scales were collected as aging structures from all recreational fish species.

General Data Analysis

Estimation of angler effort, CPUE, HPUE, catch and harvest are presented by chapter for each fishery surveyed.

Analysis of Biological Data:

Percent age composition and mean fork length (mm) at age were estimated in the harvest for humpback whitefish and least Cisco at the Chatanika River fishery. Arctic char at the Harding Lake fishery; and, Arctic grayling at the upper Chena River, Piledriver Slough, and Delta Clearwater fisheries. The standard equation for the standard error of a binomial proportion (see Cochran 1977) was used to obtain standard error estimates for the percentages by age group.

Relative Stock Density (RSD; Gabelhouse 1984) was estimated for the harvest of Arctic char at the Harding Lake fishery; and, Arctic grayling and rainbow trout at the Piledriver Slough fishery. While the minimum length of each RSD category was based on a percent age of recorded world record length, this criterion was judged as not applicable to some fish in interior Alaska. RSD categories presented for rainbow trout are those developed from historical samples of rainbow trout from interior Alaska. RSD categories presented for Arctic char in this report are those developed for rainbow trout. RSD categories presented for Arctic grayling are from Gabelhouse (1984). The standard equation for the standard error of a binomial proportion (see Cochran 1977) was used to obtain standard error estimates for the percentages by age group.

Analysis of Angler Characteristics and Angler Questionnaires:

For each fishery, angler demographics were calculated from angler interviews as a percentage of the following: male/female, adult/youth, resident/non-resident, local/non-local, tourist/military/neither, and terminal gear types used. At all fisheries, anglers interviewed were asked to rate the quality of fishing at a particular fishery. A mean rating was then calculated for each fishery from the following scale: excellent = 1, good = 2, fair = 3, poor = 4, and no opinion = 5. In addition, questions specific to each fishery were asked of anglers interviewed. Number and percent opinions to all these questions were calculated. The standard equation for the standard error of a binomial proportion (see Cochran 1977) was used to obtain standard error estimates for the percentages by age group.

CHAPTER 1 - CHATANIKA RIVER WHITEFISH SPEAR FISHERY

Introduction

The Chatanika River supports a large fall spawning run of least cisco, humpback whitefish, and round whitefish. Because of its proximity to Fairbanks (Figure 3) and the large size of this spawning run, a fall whitefish spear fishery has developed at the Chatanika River. In 1987, this fishery accounted for over 90% of the whitefish harvest in the Tanana River drainage and over 75% of the Statewide whitefish harvest (Mills 1988). Most of the whitefish harvested during the Chatanika River spear fishery are least cisco and humpback whitefish. A few round whitefish are harvested along with incidental spearing of sheefish, Arctic grayling, burbot, and longnose suckers *Catastomus catastomus*.

The whitefish spear fishery in the Tanana River drainage began in 1969. Historically, whitefish were pursued by recreational anglers with conventional rod and reel. However, because of the difficulty of catching whitefish on rod and reel, these users began to seek other means of harvesting whitefish. The result was the establishment of a spear fishing season for whitefish within the Tanana River drainage. The spear fishery on the Chatanika River developed rather slowly. A creel survey in 1970 estimated a harvest of 400 whitefish (Hallberg 1985). Estimates of harvest from 1972-1977 averaged around 2,000 whitefish. In 1986, the estimated harvest of whitefish was 19,686 fish, with estimated exploitation rates of 23% and 17% for least cisco and humpback whitefish, respectively (Clark and Ridder 1987; Hallberg and Holmes 1987). In 1987, an on-site creel survey estimated harvest at 28,591 whitefish, with exploitation rates estimated to be 43% for least cisco and 17% for humpback whitefish (Hallberg 1988; Baker 1988). This made the Chatanika River the fastest growing recreational fishery in the Tanana River drainage. Because of the high exploitation rates in 1986 and 1987, a fifteen whitefish daily bag and possession limit was instituted in 1988. Prior to 1988, there was no bag and possession limit for whitefish in the Tanana River drainage. Harvest of whitefish from the Chatanika River in 1988 was substantially reduced (about 8,000 in Mills 1989) by the imposition of possession limits.

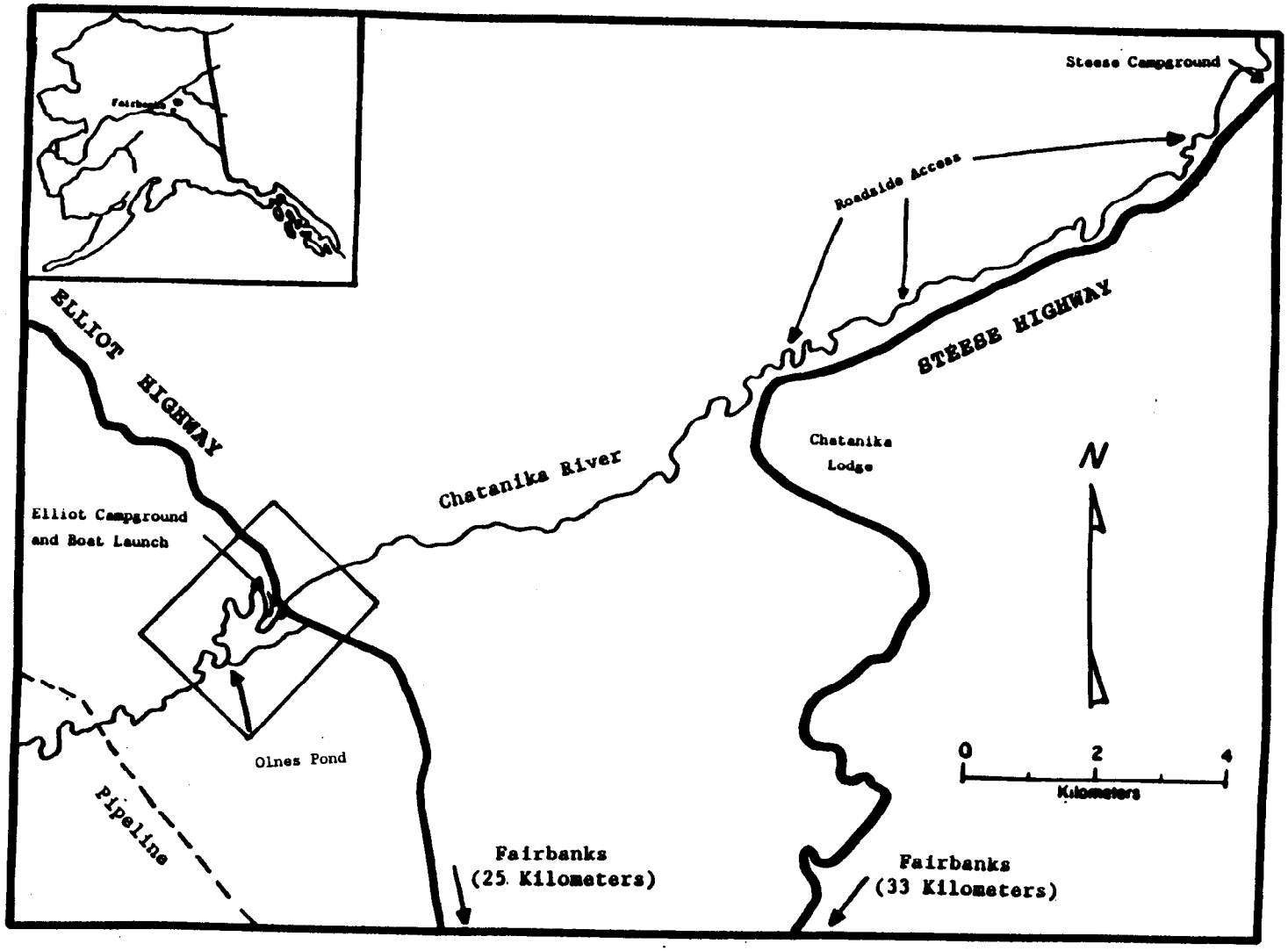

Figure 3. Map of the Elliot Campground, Olnes Pond and Steese Highway areas, Chatanika River, Tanana River drainage, Alaska.

Concern over this rapidly expanding fishery and potential effects on the stock status of whitefish prompted ADFG to initiate an in-depth research project in 1986 that has continued through 1989. The goal of this research was to estimate population abundance, harvest levels, species composition of the runs, and exploitation rates of whitefish in the spear fishery. Part of this research was a creel survey that provided information on angler-effort, harvest, and HPUE. Since 1988, age and length composition data for the harvest have been obtained during mark-recapture experiments conducted prior to the creel survey. It was found that composition data did not significantly differ between that observed during mark-recapture experiments and in the creel survey.

The specific objectives of the 1989 creel survey at the Chatanika River spear fishery were to:

1) estimate angler-effort at the Olnes Pond, Elliot Highway and Steese Highway areas;

2) estimate HPUE (harvest-per-hour) and harvest of least cisco, humpback whitefish, and round whitefish at the Olnes Pond, Elliot Highway and Steese Highway areas;

3) estimate percent age composition, Relative Stock Density (RSD), and mean fork length-at-age (mm) for each age class of least cisco and humpback whitefish;

4) estimate the percent composition of angler demographics that include: a) male/female, b) adult/youth, c) resident/non-resident/military, d) local/non-local, e) tourist/other, and f) terminal fishing gear (spinner/bait/flies/jigs/trolling/spear/bow and arrow) for the Chatanika River; and,

5) estimate the percent response (opinions) to questions asked anglers at the Olnes Pond, Elliot Highway and Steese Highway areas.

In addition, least cisco and humpback whitefish in the harvest were examined for tags, in conjunction with the whitefish population abundance project.

Methods

The majority of the spear fishing occurred in three areas (Olnes Pond or "ditch", Elliot Highway or "campground" and Steese Highway) along the Chatanika River (Figure 3). The Elliot Highway and Olnes Pond areas are located where the Elliot Highway crosses the Chatanika River. In the Elliot Highway area, spear fishing was limited to a 2 km section of river just downstream of the Elliot Highway Bridge. Spear fishing in the Olnes Pond area was limited to a 3 km section of river that is located downstream of the Elliot Highway area. The third spear fishing area is located approximately 30 km above the Elliot Highway Bridge, where the Chatanika River is accessible from the Steese Highway. At all the areas, the majority of the spear fishing was from shore, although there was a small amount of spearing from boats.

The Chatanika River whitefish creel survey was a harvest survey. The creel survey was conducted in the evenings from 2000 to 0200 hours when the majority of the spear fishing occurred. The sample period for the fishery was six hours in duration. The fishery was split into weekday (Monday through Thursday) and weekend (Friday through Sunday) strata. Sampling effort was allocated proportionally to each stratum based upon the amount of time in each stratum. Forty-three percent of sampling effort was allocated to weekend strata and 57% to weekday strata.

The creel survey was split into three sampling areas: Elliot Highway, Olnes Pond, and Steese Highway areas. Within the Elliot Highway and Olnes Pond areas, sample days were stratified into collections of consecutive and systematic selections, which occurred over the entire duration of the fishery. At the Elliot and Steese Highway areas, one angler count was conducted at a randomly selected time each hour of a six hour sample period. The remainder of each hour was spent interviewing anglers as they left the fishery. Angler counts at the Elliot Highway area were conducted by visiting three viewing locations where all anglers could be seen. The entire count took approximately 15 minutes to complete. Exit interviews were conducted at Olnes Pond, and thus direct expansion was applied for this area.

At the Steese Highway area, two samples were conducted each week for the duration of the fishery. Four angler counts were conducted during each six hour sample period. Angler counts were conducted by driving the length of Steese Highway adjacent to the Chatanika River and counting anglers at the four access points along the highway. Angler counts took approximately 20 minutes to complete. The rest of each hour was spent interviewing anglers at the different access points. Whenever possible, anglers were interviewed after they had finished spear fishing.

Harvest sampling was conducted while interviewing anglers. All least cisco and humpback whitefish encountered during the creel survey were checked for fin clips and floy tags. Scales and lengths were not collected from whitefish during the creel survey because they were collected during the population sampling portion of program conducted prior to the creel survey (Timmons 1990).

Effort, harvest, mean angler CPUE as a measure fish abundance, and demographics and opinions of anglers were estimated for the fishery at Olnes Pond with a direct-expansion, stratified two-stage sampling design. Days were primary units, anglers secondary units, and strata were collections of consecutive days. Stratification among days was necessary because there were deviations from the planned systematic selection of days. In this scheme, days were considered "randomly" selected in some strata and systematically selected in others. Sampling each night was continuous throughout the times when the fishery was prosecuted. Fishermen were interviewed and data collected as they finished their fishing trip.

Total effort in each stratum was calculated as follows with equations from Cochran (1977):

$$\hat{\bar{e}}_{hi} = \sum_{j=1}^{m_{hi}} \frac{e_{hij}}{m_{hi}} \quad (1)$$

Notation is that e and E refer to effort (hours) among anglers and total effort, respectively. Subscripts h, i, and j refer to stratum, day, and angler, respectively. Identifiers m and M are sample and population size of anglers, respectively, while d and D are days sampled and days in a stratum, respectively. Continuing the calculations for effort:

$$\hat{E}_{hi} = M_{hi}\,\hat{\bar{e}}_{hi} \quad (2)$$

$$\hat{\bar{E}}_{h} = \sum_{i=1}^{d_h} \frac{\hat{E}_{hi}}{d_h} \quad (3)$$

$$\hat{E}_{h} = D_h\,\hat{\bar{E}}_{h} \quad (4)$$

$$\hat{V}[E_h] = (1 - f_{1h})\, D_h^2 \frac{s_{1h}^2}{d_h} + D_h \sum_{i=1}^{d_h} M_{hi}^2 (1 - f_{2hi}) \frac{s_{2hi}^2}{d_h m_{hi}} \quad (5)$$

where $f_{1h} = d_h/D_h$ and $f_{2hi} = m_{hi}/M_{hi}$. Sample variances for anglers within days were calculated:

$$s_{2hi}^2 = \frac{\sum_{j=1}^{m_{hi}} (e_{hij} - \hat{\bar{e}}_{hi})^2}{m_{hi} - 1} \quad (6)$$

If days were selected randomly, the sample variance s_{1h}^2 was calculated with standard procedures:

$$s_{1h}^2 = \frac{\sum_{i=1}^{d_h} (\hat{E}_{hi} - \hat{\bar{E}}_{h})^2}{d_h - 1} \quad (7)$$

If days were selected systematically for sampling, s_{1h}^2 was calculated with procedures from Wolter (1985) to estimate variance in the presence of autocorrelation and trends:

$$s_{1h}^2 = \frac{\sum_{i=2}^{d_h} (\hat{E}_{hi} - \hat{E}_{h(i-1)})^2}{2(d_h - 1)} \qquad (8)$$

Data on harvest were substituted for data on effort in Equations 1-8 to obtain estimates of harvest for each stratum. Harvest, effort, and their variances were estimated for humpback whitefish, least cisco, and all whitefish combined. Estimates of harvest and of effort were added across strata within the fishery at Olnes Pond to obtain estimates for the season. Variances were likewise added.

Mean CPUE as a measure of angler success at Olnes Pond was also calculated from equations in Cochran (1977) and Sukhatme, et al. (1984):

$$\overline{CPUE}_{hi} = \frac{w_{hi} \sum_{i=1}^{m_{hi}} \frac{c_{hij}}{e_{hij}}}{m_{hi}} \qquad (9)$$

where the sample weight $w_{hi} = M_{hi}/\bar{M}_h$ corrects for different numbers of anglers fishing on different nights. Calculations continued to estimate mean CPUE for each stratum and its variance:

$$\overline{CPUE}_h = \frac{\sum_{i=1}^{d_h} \overline{CPUE}_{hi}}{d_h} \qquad (10)$$

$$V[\overline{CPUE}_h] = (1 - f_{1h}) \frac{s_{1h}^2}{d_h} + f_{1h} \sum_{i=1}^{d_h} (1 - f_{2hi}) \frac{s_{2hi}^2}{d_h^2 m_{hi}} \qquad (11)$$

Sample variances for anglers within days were calculated:

$$s^2_{2hi} = \frac{\sum_{j=1}^{m_{hi}} \left(w_{hi} \frac{c_{hij}}{e_{hij}} - \overline{CPUE}_{hi}\right)^2}{m_{hi} - 1} \qquad (12)$$

If days were selected randomly, the sample variance s^2_{1h} was calculated with standard procedures:

$$s^2_{1h} = \frac{\sum_{i=1}^{d_h} \left(\overline{CPUE}_{hi} - \overline{\overline{CPUE}}_h\right)^2}{d_h - 1} \qquad (13)$$

If days were selected systematically for sampling, s^2_{1h} was calculated with procedures from Wolter (1985) to estimate variance in the presence of autocorrelation and trends:

$$s^2_{1h} = \frac{\sum_{i=2}^{d_h} \left(\overline{CPUE}_{hi} - \overline{CPUE}_{h(i-1)}\right)^2}{2(d_h - 1)} \qquad (14)$$

Mean CPUE was combined across strata as weighted averages to produce unbiased estimates for the fishery at Olnes Pond:

$$\overline{\overline{CPUE}} = \sum_{h=1}^{L} \hat{W}_h \, \overline{\overline{CPUE}}_h \qquad (15)$$

$$V[\overline{\overline{CPUE}}] = \sum_{h=1}^{L} \hat{W}^2_h \, V[\overline{\overline{CPUE}}_h] \qquad (16)$$

where the W_h are the stratum weights and are calculated as the fraction of fishing trips in that stratum:

$$\hat{W}_h = \frac{\hat{A}_h}{\sum_{t=1}^{L} \hat{A}_t} \qquad (17)$$

$$\hat{A}_h = \frac{D_h \sum_{i=1}^{d_h} M_{hi}}{d_h} \tag{18}$$

In the opinion and demographic surveys conducted at Olnes Pond, five attributes of anglers (sex, age, residency, and military status) were recorded and three questions on regulations with four, three, and three possible answers were asked anglers. Each attribute was coded as a binomial variate while each answer as a multinomial variate. Mean fraction of the population fishing at Olnes Pond were estimated from fractions averaged across sampled days:

$$\hat{\bar{p}}_h = \frac{\sum_{i=1}^{d_h} w_{hi}\hat{p}_{hi}}{d_h} \tag{19}$$

where p is the fraction of anglers of a given type or with a given opinion. The variance from Cochran (1977) is:

$$\hat{V}[p_h] = (1 - f_{1h}) \frac{s_{1h}^2}{d_h} + f_{1h} \sum_{i=1}^{d_h} (1 - f_{2hi}') w_{hi}^2 \frac{\hat{p}_{hi}(1-\hat{p}_{hi})}{d_h^2(m_{hi}'-1)} \tag{20}$$

where m_{hi}' was the number of anglers who were interviewed and $f_{2hi}' = m_{hi}'/M_{hi}$. If days were selected randomly, the sample variance was calculated with standard procedures:

$$s_{1h}^2 = \frac{\sum_{i=1}^{d_h} (w_{hi}\hat{p}_{hi} - \hat{\bar{p}}_h)^2}{d_h - 1} \tag{21}$$

If days were selected systematically for sampling, the sample variance was calculated with procedures from Wolter (1985) to estimate variance in the presence of autocorrelation and trends:

$$s_{1h}^2 = \frac{\sum_{i=2}^{d_h} (w_{hi}\hat{p}_{hi} - w_{h(i-1)}\hat{p}_{h(i-1)})^2}{2(d_h - 1)} \tag{22}$$

Estimates of proportions across strata within the survey at Olnes Pond were calculated as weighted averages. Equations 15-16 were used with mean proportions substituted for mean CPUE. The same strata weights calculated in Equations 17-18 were used here.

Effort, harvest, mean angler CPUE as a measure fish abundance, and demographics and opinions of anglers were estimated for fisheries at the Elliot Highway Bridge and the Steese Highway Bridge with roving, stratified two-stage sampling designs. Days were primary units, anglers secondary units, and strata were collections of consecutive days. Stratification among days was necessary because there were deviations from the planned systematic selection of days. In this scheme, days were considered "randomly" selected in some strata and systematically selected in others. Sampling each night was continuous throughout the times when the fishery was prosecuted.

Effort was calculated by counting anglers during sampling periods and expanding the average counts for the time in sampling periods. The average number of anglers from several systematically scheduled counts were:

$$\bar{x}_{hi} = \frac{\sum_{j=1}^{r_{hi}} x_{hij}}{r_{hi}} \qquad (23)$$

with x as the number of fishermen counted and r as the number of counts made in a sampling period. Effort and its variance were calculated by expanding for the length of sampling periods (H = 6 hr):

$$\hat{E}_{hi} = H\,\bar{x}_{hi} \qquad (24)$$

$$\hat{V}[E_{hi}] = H^2 \frac{\sum_{j=2}^{r_{hi}} (x_{hij} - x_{hi(j-1)})^2}{2\, r_{hi}(r_{hi} - 1)} \qquad (25)$$

Mean CPUE* (not the same $\overline{CPUE}$ as an index of abundance) was calculated as a ratio estimator for expansion:

$$\overline{CPUE}^{*}_{hi} = \frac{\sum_{j=1}^{m_{hi}} c_{hij}}{\sum_{j=1}^{m_{hi}} e_{hij}} \qquad (26)$$

Since this estimator has an inherent bias of order m_{hji}^{-1}, a jackknifed estimator (similar to procedures outlined in equations 38 through 41) with a

smaller, correctable bias (m_{hji}^{-2}) was used (Cochran 1977). A test was conducted and no difference was found between harvest rates of anglers at the finish of their trip or while they were fishing, all data were combined in estimating mean CPUE* for each day sampled. Variance of mean $CPUE^*_{hi}$ was estimated through the jackknife procedure (similar to procedures outlined in equation 49). Effort was then expanded by mean CPUE* to estimate harvest (C) for each day sampled and its variance:

$$\hat{C}_{hi} = \overline{CPUE}^*_{hi} \hat{E}_{hi} \tag{27}$$

$$\hat{V}[C_{hi}] = \hat{E}^2_{hi} V[\overline{CPUE}^*_{hi}] + \overline{CPUE}^{*2}_{hi} \hat{V}[E_{hi}] - V[\overline{CPUE}^*_{hi}] \hat{V}[E_{hi}] \tag{28}$$

Estimated harvest for a stratum was then calculated with Equations 3 and 4; its variance was calculated:

$$\hat{V}[C_h] = (1 - f_{1h}) D_h^2 \frac{s^2_{1h}}{d_h} + D_h \sum_{i=1}^{d_h} R \frac{\hat{V}[C_{hi}]}{d_h} \tag{29}$$

Sample variance for the first stage (s^2_{1h}) was calculated as in Equation 7 or 8 depending on how days were selected for sampling.

Mean CPUE as an index of abundance was also calculated for the fisheries at the Elliot and Steese Highways. Equations 9-10, 12 and 13 or 14 were used with sample weights w_{hi} calculated using angler counts as:

$$\bar{x}_h = \frac{\sum_{i=1}^{d_h} R \bar{x}_{hi}}{d_h} \tag{30}$$

$$w_{hi} = \frac{\bar{x}_{hi}}{\bar{x}_h} \tag{31}$$

Variance of mean CPUE was calculated as:

$$V[\overline{CPUE}_h] = (1 - f_{1h}) \frac{s^2_{1h}}{d_h} + f_{1h} \sum_{i=1}^{d_h} R \frac{s^2_{2hi}}{d_h^2 m_{hi}} \tag{32}$$

Binomial and multinomial statistics were also calculated from the demographic and opinion surveys conducted at fishing sites on the Elliot and Steese Highways. Mean proportions for each stratum were calculated according to Equation 19 and its variance:

$$\hat{V}[p_h] = (1 - f_{1h}) \frac{s_{1h}^2}{d_h} + f_{1h} \sum_{i=1}^{d_h} w_{hi}^2 \frac{\hat{p}_{hi}(1-\hat{p}_{hi})}{d_h^2(m_{hi}'-1)} \quad (33)$$

Sample variance s_{1h}^2 was calculated according to Equation 21 or 22 depending on how days were selected for sampling.

Information from each stratum within the surveys of the upstream fisheries were combined to produce totals within each fishery and overall the fisheries combined. Totals such as harvest and effort were added as were their variances. Mean CPUE and mean proportions across strata within the upstream fisheries and across all fisheries were calculated as weighted averages in Equations 15-17. However, estimates of the number of fishing trips in the upstream fisheries with roving surveys were calculated with estimates of effort:

$$\hat{A}_h = \frac{E_h \hat{\sum}_{i=1}^{d_h} m_{hi}}{\sum_{i=1}^{d_h} \sum_{j=1}^{m_{hi}} e_{hij}} \quad (34)$$

In Equation 35, only effort statistics (e_{hij}) from anglers who had finished their fishing trip were used.

Results and Discussion

The harvest survey began 9 September and continued through 16 October. An estimated total of 2,518 fishing trips were completed in the whitefish fishery at the combined areas of Olnes Pond, Elliot Highway, and Steese Highway (Table 2). Estimated angler-effort in the three areas was 5,950 hours (SE = 600), with a combined harvest of 16,068 whitefish (SE = 1,611).

Of the estimated total number of fishing trips, 55% (1,374) were in the Olnes Pond area (Table 3), where 59% of the total estimated angler-effort was expended (3,484 hours, SE = 359). The estimated HPUE of least cisco in the Olnes Pond area was 1.70 (SE = 0.24), and of humpback whitefish was 0.76 (SE = 0.12). An estimated total of 10,986 (SE = 1,012) whitefish were harvested from the Olnes Pond area, of which 2,547 (SE = 414) or 23% were humpback whitefish and 6,034 (SE = 1,022) or 55% were least cisco. The greatest harvest occurred from 11-30 September (Table 3).

Nine hundred sixty-five fishing trips (38%) were estimated at the Elliot Highway area (Table 4). Estimated angler-effort for this area was 37% of the total or 2,200 hours (SE = 474). The estimated HPUE of humpback whitefish in the Elliot Highway area was 0.46 (SE = 0.23). HPUE of least cisco was 1.62

Table 2. Effort and harvest statistics for whitefish in all fisheries, Chatanika River, Tanana River drainage, Alaska, 1989.

Stratum	Species	Fishing Trips	Effort (Angler Hours)	SE	HPUE[b]	SE	Harvest	SE
	All	2,518	5,950	600	2.50[a]	0.28[a]	16,068[a]	1,611
	Humpback	---	---	---	0.64	0.11	3,835	491
	Least Cisco	---	---	---	1.55	0.24	9,784	1,443

[a] Statistics are for all whitefish, including humpback whitefish, least cisco, round whitefish, and unidentified whitefish.

[b] Harvested fish per hour.

Table 3. Effort and harvest statistics for Olnes Pond whitefish, Chatanika River, Tanana River drainage, Alaska, 1989.

Stratum	Species	M[b]	Fishing Trips	Effort (Angler Hours)	SE	HPUE[c]	SE	Harvest	SE
Sept 11 - 30	All	232	804	1,985	202	3.11[a]	0.20[a]	6,305[a]	509[a]
	Humpback		---	---	---	0.43	0.09	799	187
	Least Cisco		---	---	---	1.55	0.36	3,179	877
Oct 1 - 4	All	45	160	429	126	3.48[a]	0.53[a]	1,364[a]	350[a]
	Humpback		---	---	---	1.02	0.31	416	123
	Least Cisco		---	---	---	2.32	0.33	915	250
Oct 5 - 10	All	100	282	788	264	3.19[a]	0.94[a]	2,472[a]	766[a]
	Humpback		---	---	---	1.23	0.47	911	338
	Least Cisco		---	---	---	1.92	0.49	1,533	436
Oct 11 - 15	All	71	128	281	46	2.91[a]	0.64[a]	845[a]	233[a]
	Humpback		---	---	---	1.43	0.29	422	86
	Least Cisco		---	---	---	1.39	0.52	408	152
Total	All	448	1,374	3,484	359	3.01[a]	0.24[a]	10,986[a]	1,012[a]
	Humpback		---	---	---	0.76	0.12	2,547	414
	Least Cisco		---	---	---	1.70	0.24	6,034	1,022

[a] Statistics are for all whitefish, including humpback whitefish, least cisco, round whitefish, and unidentified whitefish.

[b] M = total number of anglers interviewed.

[c] Harvested fish per hour.

Table 4. Effort and harvest statistics for Elliot Highway whitefish, Chatanika River, Tanana River drainage, Alaska, 1989.

Stratum	Species	M[b]	Fishing Trips	Effort (Angler Hours)	SE	HPUE[c]	SE	Harvest	SE
Sept 12 - 18	All	33	135	154	120	0.03[a]	0.08[a]	4[a]	5[a]
	Humpback		---	---	---	0.02	0.07	1	3
	Least Cisco		---	---	---	0.00	0.00	0	0
Sept 19 - 26	All	92	228	482	221	1.62[a]	1.36[a]	807[a]	755[a]
	Humpback		---	---	---	0.26	0.27	147	132
	Least Cisco		---	---	---	1.36	1.18	656	625
Sept 27 - Oct 4	All	96	300	822	369	3.52[a]	1.36[a]	2,521[a]	930[a]
	Humpback		---	---	---	0.71	0.65	475	179
	Least Cisco		---	---	---	2.80	1.31	2,036	760
Oct 5 - 6	All	71	72	199	65	2.53[a]	1.16[a]	440[a]	136[a]
	Humpback		---	---	---	0.48	0.45	95	32
	Least Cisco		---	---	---	2.02	1.00	339	106
Oct 7 - 14	All	89	230	543	146	1.74[a]	1.02[a]	1,115[a]	329[a]
	Humpback		---	---	---	0.57	0.38	381	95
	Least Cisco		---	---	---	1.15	0.74	719	239
Total	All	381	965	2,200	474	2.08[a]	0.65[a]	4,887[a]	1,250[a]
	Humpback		---	---	---	0.46	0.23	1,099	244
	Least Cisco		---	---	---	1.62	0.53	3,750	1,018

[a] Statistics are for all whitefish, including humpback whitefish, least cisco, round whitefish, and unidentified whitefish.

[b] M = total number of anglers interviewed.

[c] Harvested fish per hour.

(SE = 0.53). Total harvest of whitefish in the area was 4,887 (SE = 1,250); 22% or 1,099 (SE = 244) were humpback whitefish and 77% or 3,750 (SE = 1,018) were least cisco. The greatest harvest occurred from 27 September to 4 October (Table 4).

In the Steese Highway area, there were an estimated 179 fishing trips, or 7% of total fishing trips in the Chatanika River whitefish fishery (Table 5). Angler-effort in the Steese Highway area was estimated at 266 hours (SE = 78), contributing to only 4% of the total effort. Estimated HPUE of humpback whitefish in the area was 0.75 (SE = 0.37). Humpback whitefish comprised 96% (189, SE = 99) of the total estimated harvest in the Steese Highway area which was 196 whitefish (SE = 98). No least cisco were harvested in the Steese Highway area.

In this fishery, CPUE and catch are the same as HPUE and harvest.

The harvest of least cisco per angler-hour peaked at 3.3 - 4.5 around 25-28 September at the Olnes Pond and Elliot Highway areas. While high harvests of least cisco continued until 5 October at Olnes Pond, harvest dropped off at the Elliot Highway until a second peak occurred on 12 October (Figure 4). The harvest per angler-hour of humpback whitefish peaked at Olnes Pond on 18 September, then declined, until 23 September when harvest per angler-hour began to increase. Harvest of humpback whitefish per angler-hour at the Elliot Highway showed sporadic peaks beginning on 2 October (Figure 4). Approximately 25% of anglers had harvested zero whitefish at the time of the interview; whereas about 10% of anglers had achieved their bag limit of 15 whitefish (Figure 5). Some anglers interviewed had harvested more than the legal bag limit. Percent age composition and mean fork length-at-age for each species is in Timmons (1990).

Of the estimated 2,574 anglers at the three combined areas of the Chatanika River, the typical angler was male (83%), adult (95%), a resident of Alaska (99%), non-military (88%), and from the Fairbanks-North Pole area (89%; Table 6).

Opinions of anglers interviewed in the three areas differed. In the Olnes Pond area, the median rating of the quality of spear fishing in the Chatanika River was 2, a rating of good (Table 7). A majority of the interviewed anglers (76%) approved of the 15 whitefish daily bag and possession limit for the Chatanika River. Those that disapproved of the current limit were split as to what it should be. Thirty percent wanted a limit greater than 30, 46% thought it should be between 15 and 30, and 24% thought it should be less than 15.

Anglers in the Elliot Highway area also rated the quality of fishing in the area as good (median rating 2; Table 8) and approved of the 15 whitefish limit. Only 3% of the anglers disapproving of the limit thought it should be less, 56% thought it should be between 15 and 30 while 41% thought it should be more than 30.

The quality of spear fishing in the Chatanika River was given a lower average rating by anglers in the Steese Highway area than those in other areas.

Table 5. Effort and harvest statistics for Steese Highway whitefish, Chatanika River, Tanana River drainage, Alaska, 1989.

Stratum	Species	M[b]	Fishing Trips	Effort (Angler Hours)	SE	HPUE[c]	SE	Harvest	SE
Sept 12 - Oct 10	All	46	179	266	78	0.76[a]	0.37[a]	196[a]	98[a]
	Humpback		---	---	---	0.75	0.37	189	99
	Least Cisco		---	---	---	0.00	0.00	0	0

[a] Statistics are for all whitefish, including humpback whitefish, least cisco, round whitefish, and unidentified whitefish.

[b] M = total number of anglers interviewed.

[c] Harvested fish per hour.

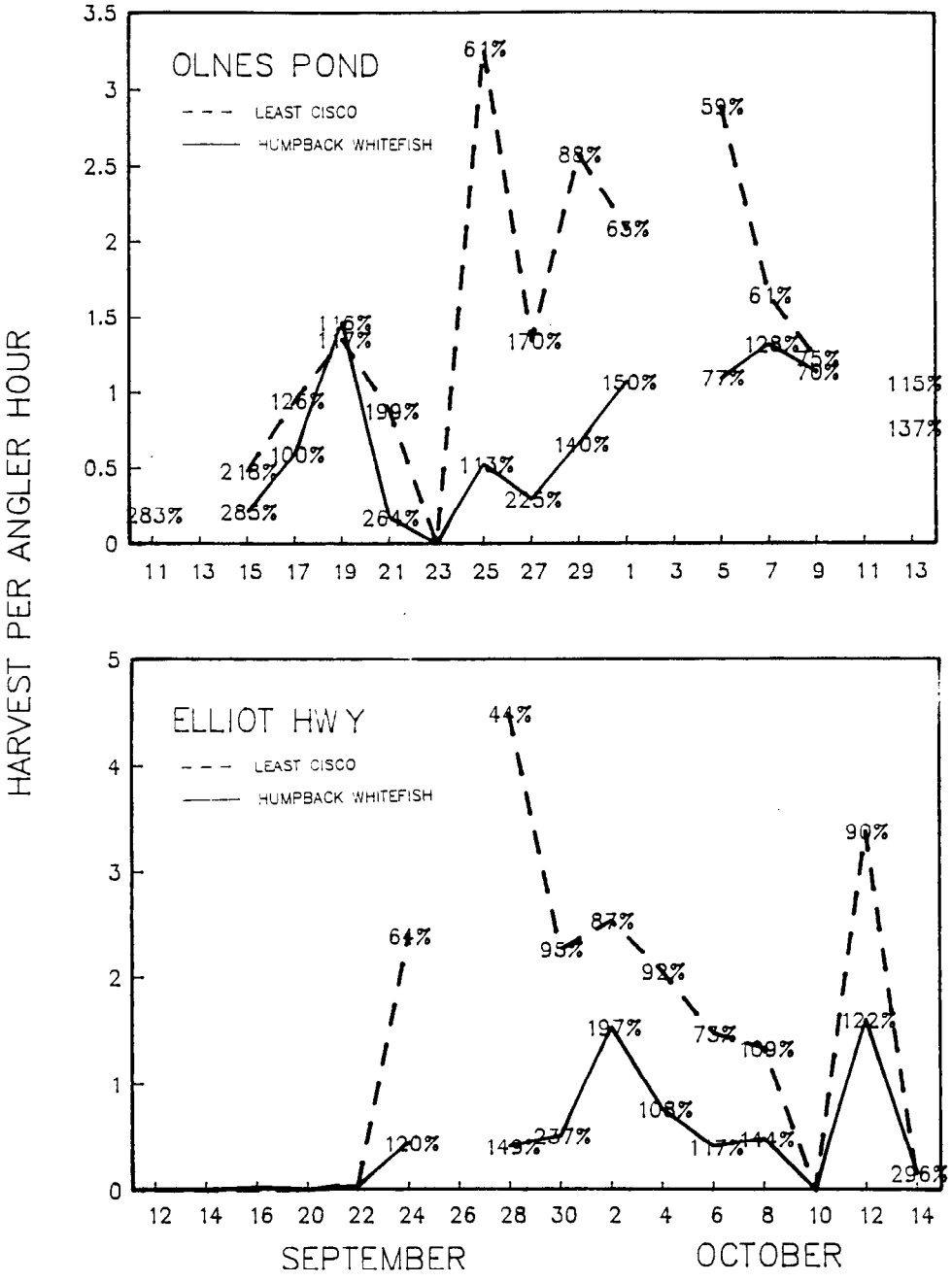

Figure 4. Harvest per angler hour of least cisco and humpback whitefish at Olnes Pond and the Elliot Campground, Chatanika River, for September and October, 1989. Percent coefficient of variation is presented for point estimates.

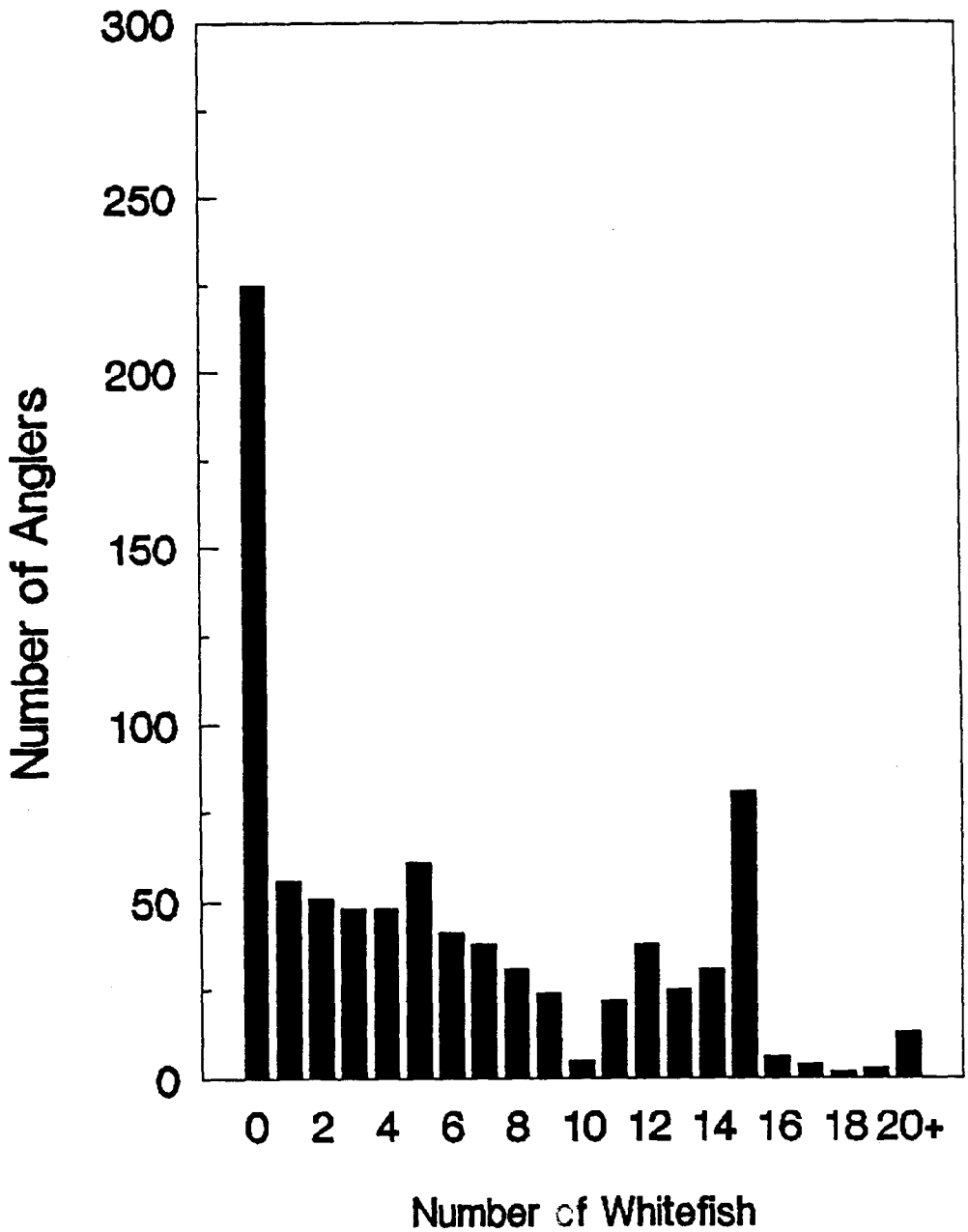

Figure 5. Distribution of whitefish harvest among anglers interviewed at the Chatanika River, Tanana River drainage, Alaska, 1989.

Table 6. Demographic profile of anglers interviewed at the Chatanika River (combined areas), Tanana River drainage, Alaska, 1989.

Angler Characteristic	n	%	SE (%)	Angler Characteristic	n	%	SE (%)
Total Number of Anglers	2,574	--	--	Local[a]	2,291	89	5
				Non-local	283	11	5
Male	2,136	83	4	Resident	2,548	99	4
Female	438	17	4	Non-Resident	26	1	4
Adult	2,445	95	5	Military	309	12	2
Youth	129	5	5	Non-Military	2,265	88	2

[a] Local and non-local category includes Alaska residents only. Local category are anglers from the Fairbanks-North Pole area.

Table 7. Opinions of anglers interviewed at the Olnes Pond Campground of the Chatanika River, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%	SE (%)
1. How would you rate the quality of spear fishing at the Chatanika River this year?	Excellent (1)	71	5	2
	Good (2)	744	52	7
	Fair (3)	343	24	3
	Poor (4)	272	19	3
	Total[a]	1,430	100	Wt[c]0.56
	Mean Rating[b]	2.57		
	Median Rating[b]	2		
2. What is your opinion of the 15 whitefish daily bag and possession limit for the Chatanika River?	Approve	1,087	76	10
	Disapprove	214	15	2
	No Opinion	129	9	6
	Total[a]	1,430	100	Wt[c]0.56
3. If you disapprove of the whitefish limit, what should be the daily bag and possession limit for the whitefish in the Chatanika River?	More than 30	63	30	8
	15 to 30	96	46	13
	less than 15	50	24	8
	Total[a]	209	100	Wt[c]0.60

[a] Estimated total anglers.
[b] Rating is from the actual number of anglers interviewed.
[c] Weighting factor.

Table 8. Opinions of anglers interviewed at the Elliot Highway of the Chatanika River, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%	SE (%)
1. How would you rate the quality of spear fishing at the Chatanika River this year?	Excellent (1)	68	7	4
	Good (2)	454	47	8
	Fair (3)	183	19	4
	Poor (4)	260	27	5
	Total[a]	965	100	Wt[c]0.38
	Mean Rating[b]	2.66		
	Median Rating[b]	2		
2. What is your opinion of the 15 whitefish daily bag and possession limit for the Chatanika River?	Approve	791	82	9
	Disapprove	145	15	5
	No Opinion	29	3	2
	Total[a]	2,574	100	Wt[c]0.38
3. If you disapprove of the whitefish limit, what should be the daily bag and possession limit for the whitefish in the Chatanika River?	More than 30	58	41	10
	15 to 30	80	56	16
	less than 15	4	3	3
	Total[a]	142	100	Wt[c]0.41

[a] Estimated total anglers.
[b] Rating is from the actual number of anglers interviewed.
[c] Weighting factor.

Steese area anglers gave the fishery a rating of 4, or poor (Table 9). All of the interviewed anglers approved of the 15 daily bag and possession limit for whitefish.

Overall, anglers interviewed at the Chatanika River found the fishing to be good (median rating 2; Table 10), and approved of the daily limit of whitefish (80%). Half of those disapproving of the limit thought it should be greater than 15 but less than 30. Thirty four percent thought it should be more than 30 and 16% thought it should be less than 15.

The whitefish harvest for the Chatanika River spear fishery in 1989 was estimated to be 16,068 fish, compared to 28,591 fish in 1987 (Baker 1988). This was a 44% reduction in whitefish harvest from 1987 to 1989. The majority of the reduction was in the least cisco harvest. The harvest estimate for least cisco was 23,735 fish in 1987 and 9,784 fish in 1989. This was a 59% reduction in least cisco harvest from 1987 to 1989. However, humpback whitefish harvest only shifted from 4,577 fish in 1987 to 3,835 fish in 1989, which was a 16% reduction in humpback whitefish harvest. These reductions were the result of the 15 whitefish daily bag and possession limit instituted in 1988. Based on the distribution of harvest among anglers in 1987, it was predicted that the 15 whitefish bag limit would reduce harvest by 70% (Baker 1988), which is greater than the 44% that harvest was actually reduced. Harvest was not reduced as expected, due in part to increased angler effort in 1989 (5,950 angler hours) as compared to 1988 (3,974 angler hours).

While the creel survey in 1988 was expanded to include the Steese Highway area, in 1989 anglers in the Steese Highway area accounted for 1% of the total whitefish harvest in the Chatanika River spear fishery. Based on the amount effort put forth to provide this estimate, it is recommended that this portion of the creel survey not be conducted in the future. However, this area should be checked periodically to make sure there are no dramatic shifts in angler-effort or harvest in the future. Elimination of the Steese Highway area from future creel surveys will make the harvest estimate for humpback whitefish a minimum estimate because a small portion of the harvest is being excluded.

CHAPTER 2 - UPPER CHENA RIVER ARCTIC GRAYLING FISHERY

Introduction

One of the largest Arctic grayling fisheries in Alaska occurs at the upper Chena River. This fishery attracts a large number of anglers because of its close proximity to Fairbanks and because the majority of the fishery is accessible by road (Figure 6). The upper Chena River fishery occurs mainly within the Chena River State Recreation Area. This is one of the first open-water fisheries to open during the spring within the Fairbanks area. The early season fishery continues throughout the open-water period with the majority of the angling effort expended during the months of June, July, and August.

Some type of creel survey has been conducted at the upper Chena River almost every year since 1970 (Holmes 1985). Annual sport harvest has been estimated

Table 9. Opinions of anglers interviewed at the Steese Highway of the Chatanika River, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%	SE (%)
1. How would you rate the quality of spear fishing at the Chatanika River this year?	Excellent (1)	0	0	0
	Good (2)	79	44	16
	Fair (3)	7	4	4
	Poor (4)	93	52	13
	Total[a]	179	100	Wt[c]0.07
	Mean Rating[b]	3.08		
	Median Rating[b]	4		
2. What is your opinion of the 15 whitefish daily bag and possession limit for the Chatanika River?	Approve	179	100	0
	Disapprove	0	0	0
	No Opinion	0	0	
	Total[a]	179	100	Wt[c]0.07
3. If you disapprove of the whitefish limit, what should be the daily bag and possession limit for the whitefish in the Chatanika River?	More than 30	0	--	--
	15 to 30	0	--	--
	less than 15	0	--	--
	Total	0		

[a] Estimated total anglers.
[b] Rating is from the actual number of anglers interviewed.
[c] Weighting factor.

Table 10. Opinions of anglers interviewed at the Chatanika River, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%	SE (%)
1. How would you rate the quality of spear fishing at the Chatanika River this year?	Excellent (1)	129	5	2
	Good (2)	1,287	50	5
	Fair (3)	540	21	2
	Poor (4)	618	24	3
	Total[a]	2,574	100	Wt[c]1.00
	Mean Rating[b]	2.64		
	Median Rating[b]	2		
2. What is your opinion of the 15 whitefish daily bag and possession limit for the Chatanika River?	Approve	2,059	80	7
	Disapprove	360	14	2
	No Opinion	155	6	3
	Total[a]	2,574	100	Wt[c]1.00
3. If you disapprove of the whitefish limit, what should be the daily bag and possession limit for the whitefish in the Chatanika River?	More than 30	119	34	6
	15 to 30	176	50	10
	less than 15	56	16	5
	Total[a]	351	100	Wt[c]1.00

[a] Estimated total anglers.
[b] Rating is from the actual number of anglers interviewed.
[c] Weighting factor.

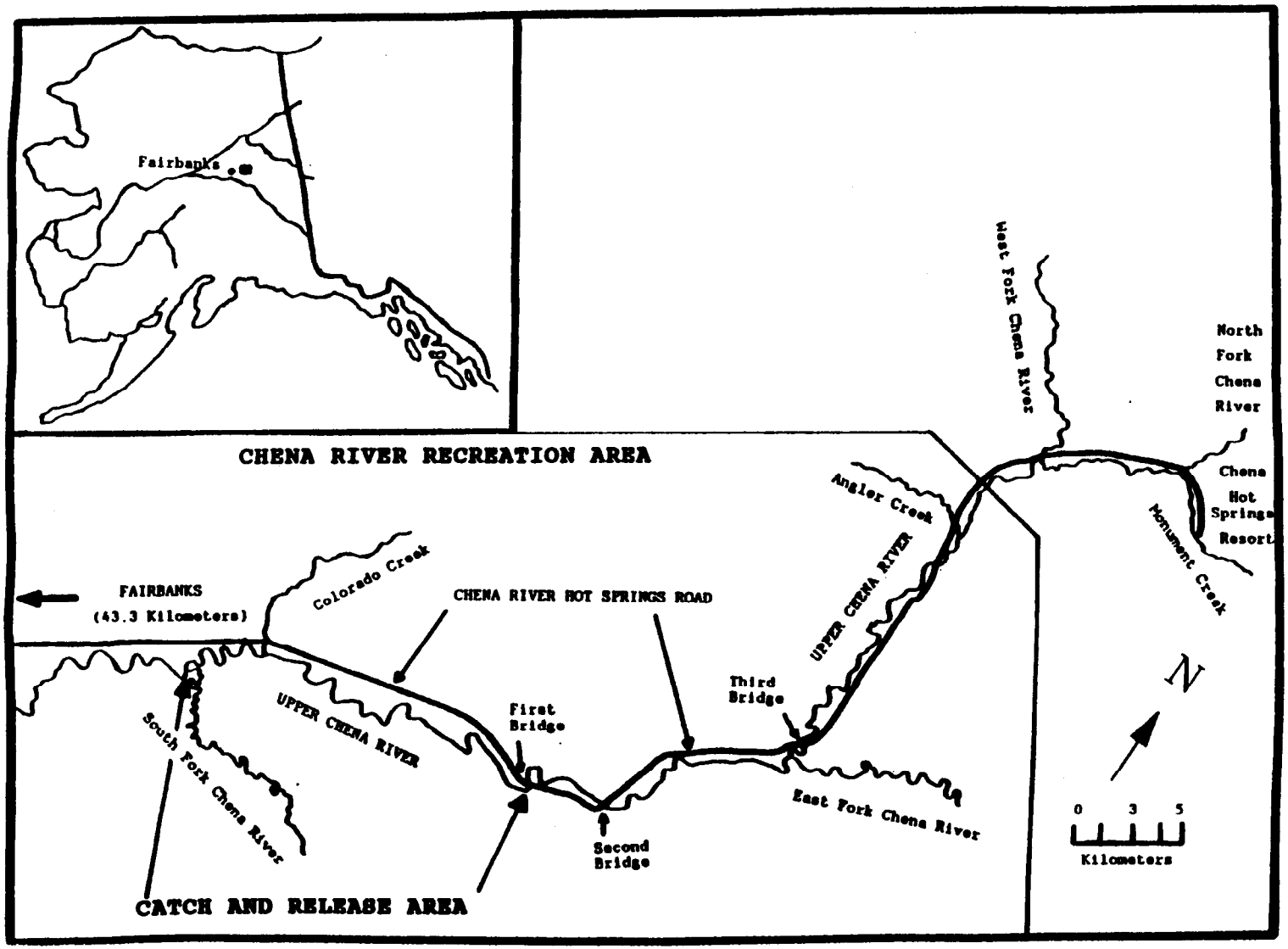

Figure 6. Map of the upper Chena River, Tanana River drainage, Alaska.

by the statewide postal survey beginning in 1977 (Mills 1979-1989). Angler effort has ranged from 22,657 angler-hours in 1975 to a low of 9,090 angler-hours in 1987 (Table 11). Both harvest (18,049) and HPUE (1.55 Arctic grayling per hour) peaked in 1974. Since 1981, both harvest and HPUE of Arctic grayling have declined. The mean length of harvested Arctic grayling for the past ten years has been 246 mm and the proportion of quality grayling (> 300 mm) has ranged from 10% to 30%. The relatively small mean length and decreased abundance of grayling are commonly commented on by anglers (Holmes 1985). For these reasons, a series a fishery management regulations were implemented at the upper Chena River grayling fishery that included:

1) a 12 inch minimum length limit for Arctic grayling;

2) a no-bait restriction on the upper Chena River; and,

3) catch and release Arctic grayling fishing from 1 April to the first Saturday of June each year at the upper Chena River.

These regulations were put into effect in 1987 to help sustain the declining Arctic grayling stock of the upper Chena River and still provide angling opportunity. Harvest declined drastically from 16,390 in 1980 to a low of 1,260 in 1987. HPUE during the same time period dropped from 0.80 fish-per-hour to 0.14 fish-per-hour in 1987 and 1988. Catch increased from 1986 to 1987, with catch decreasing slightly in 1988.

To provide a diversity of angling opportunities within the Tanana River drainage, a section of the upper Chena River from the confluence of the South Fork of the Chena River (river kilometer 128) upstream to the first bridge on the Chena Hot Springs Road (river kilometer 147) was designated as catch-and-release fishing in 1988. In spite of restrictive regulatory measures, further action was required to protect Arctic grayling stocks in the Chena River. In February of 1990, the Board of Fisheries lowered the daily bag and possession limit to two Arctic graying, 12 inches or greater in length, and restricted upstream fishing to unbaited single-hook artificial lures only. This action was intended to reduce the harvest and allow a more rapid recovery and rebuilding of the stocks in the Chena River.

The specific objectives of the upper Chena River creel survey were to:

1) estimate the amount angler-effort expended at the upper Chena River;

2) estimate CPUE, HPUE, catch, and harvest for Arctic grayling at the upper Chena River;

3) estimate percent age composition of Arctic grayling in the harvest sample from the upper Chena River;

4) estimate the percent composition of angler demographics for the upper Chena River that include: a) male/female, b) adult/youth, c) resident/non-resident/military, d) local/ non-local, e) tourist/other, and f) terminal fishing gear (spinner/bait/flies/jigs/trolling/ spear/bow and arrow);

Table 11. Creel survey results for the upper Chena River Arctic grayling fishery, 1970-1988.

Year[a]	Date	Days of Survey	Angler Effort[b]	HPUE[c]	CPUE[d]	Harvest	Catch
1970	1 May - 31 May 14 Jul - 29 Aug	78	12,518	0.54	---	6,770	---
1972	25 May - 27 Aug	95	13,116	0.77	---	10,099	---
1974	1 Jul - 31 Aug	62	11,680	1.55	---	18,049	---
1975[e]	1 Jun - 31 Aug	92	22,657	0.62	---	14,067	---
1976	1 Jun - 31 Aug	92	10,752	0.39	---	4,161	---
1977	1 Jun - 31 Aug	92	13,536	0.69	---	9,406	---
1978	29 May - 31 Aug	95	10,508	0.65	---	6,898	---
1979	1 Jun - 31 Aug	92	12,744	0.82	---	10,459	---
1980	8 May - 30 Sep	144	20,827	0.78	---	16,390	---
1981	1 May - 31 Aug	123	15,896	0.80	---	13,549	---
1982	1 May - 15 Sep	138	20,379	0.62	---	12,603	---
1983	1 May -15 Sep	138	19,018	0.58	---	10,821	---
1984	6 May - 15 Sep	132	17,090	0.59	---	9,623	---
1985	8 May - 5 Sep	121	10,613	0.22	---	2,335	---
1986	1 May - 15 Sep	138	10,716	0.31	0.48	3,326	5,148
1987[f]	18 May - 15 Sep	121	9,090	0.14	0.78	1,260	6,997
1988	14 May - 18 Sep	128	11,763	0.14	0.57	1,583	6,714

[a] Data prior to 1982 from Hallberg (1982).

[b] Number of angler-hours.

[c] Number of Arctic grayling caught and kept per hour.

[d] Number of Arctic grayling caught per hour.

[e] Daily bag limit for Arctic grayling was reduced from 10 fish to 5 fish.

[f] Management regulations were initiated prior to this fishing season that included: (1) Catch and release Arctic grayling from 1 April to the first Saturday in June; (2) A 12 inch minimum length limit; and, (3) A no-bait restriction (flies and lures only).

5) estimate the percent response to questions asked of anglers interviewed; and,

6) estimate the rating by anglers of the quality of fishing.

Methods

The upper Chena River grayling fishery occurs along a 43.3 km section of the Chena Hot Springs Road that parallels the Chena River (Figure 6). Numerous access points are available to anglers including eight bridges, three state campsites, and four access roads. Approximately 90% of the angler-effort occurs from shore near these access sites (Holmes 1981). A small proportion of anglers reach the more remote areas by floating between the access points. Within this area is a section of the river from the confluence of the South Fork of the Chena River (river kilometer 128) upstream to the first bridge on the Chena Hot Springs Road (river kilometer 147) that is designated as catch-and-release only for Arctic grayling.

The field procedure was as follows. At the start of a two-hour sampling period, a coin was tossed to determine at which end of the count area the count would begin. Angler counts were made by driving the main road and all side roads on which anglers were located within the 43.3 km section. Angler counts took approximately 60-90 minutes to complete. The remainder of the sample period was spent conducting angler interviews. Complete-trip interviews were preferred. However, the majority of the anglers interviewed were interviewed while they were still fishing (incomplete-trip). The harvest was sampled while interviewing anglers

A roving-type creel survey (Neuhold and Lu 1957) was used to obtain angler, effort, catch, and harvest for the upper Chena River Arctic grayling fishery. The fishery was sampled using a stratified multi-stage sample survey. Strata were defined as follows:

1. 19 May-30 June, weekdays[1], "all day"[2];
2. 19 May-30 June, weekend-holidays[3], "peak hours"[4];
3. 19 May-30 June, weekend-holidays, "non-peak hours"[5];
4. 1-31 July, weekdays[6], "peak hours";
5. 1-31 July, weekdays, "non-peak hours";
6. 1-31 July, weekend-holidays[7], "peak hours";
7. 1-31 July, weekend-holidays, "non-peak hours";
8. 1 August-13 September, weekdays[8], "peak hours";

---

1 Including Mondays through Fridays, excluding the 29 May memorial day holiday.

2 Including the hours from 0800 to 2300 each day.

3 Including Saturdays and Sundays, and the 29 May memorial day holiday.

4 Including the hours from 1100 to 1900 each day.

5 Including the hours from 0800 to 1100 and 1900 to 2300 each day.

6 Including Mondays through Fridays, excluding the 4th of July holiday.

7 Including Saturdays and Sundays, and the 4th of July holiday.

8 Including Mondays through Fridays, excluding the 3 September Labor day holiday.

9. 1 August-13 September, weekdays, "non-peak hours";
10. 1 August-13 September, weekend-holidays[9], "peak hours"; and,
11. 1 August-13 September, weekend-holidays, "non-peak hours".

Within each stratum days were sampled at random and represent the first stage of sampling. Within each sampled day, sample periods were selected at random from the available hours in each sampling day (i.e., the hours of 1100 to 1900 for the "peak hours" strata). In general only one sample period per day within a stratum was selected for surveying. Accordingly, although the sample period truly represented the second stage of sampling, it was not treated as such (since the among sampling period component of variance could not be consistently estimated). Within each stratum, on each selected day the anglers interviewed represented the second sampling stage for catch and harvest rate calculations. Only one angler count was conducted during each sampled period. Counts were conducted concurrently during the angler interview process as the fishery was roved by the creel clerk. The counts conducted within each stratum on each selected day were treated as the second sampling stage for angler effort estimation.

A review of the data collected during 1989 indicated that during some sampling periods no anglers were interviewed, however anglers were fishing (i.e., count greater than zero). Accordingly, the approach used to obtain catch and harvest estimates was to obtain stratum estimates of angler effort, catch and harvest rates, i.e., CPUE and HPUE; and then to multiply the CPUE and HPUE stratum estimates by the stratum angler effort estimates to obtain the catch and harvest stratum estimates, respectively. Both completed-trip and incompleted-trip angler interviews were used to estimate the catch and harvest rates for expansion purposes due to the low number of completed-trip interviews.

The CPUE and HPUE estimates were obtained by the jackknife estimation approach (Efron 1982). The jackknife approach for estimating CPUE and HPUE was used since most other estimators are known to be biased (for use as ratio estimators, i.e., for expansion), and the jackknife estimate has been shown to be less biased and procedures exist for correcting this bias (see Cochran 1977, section 6.15, pages 174-177; and Smith 1980). Prior to applying the jackknife procedure each angler's catch and harvest was weighted by the relative numbers of anglers utilizing the fishery during the interview period (as measured from the angler count). This weighting procedure ensures that each sample period's interview information was proportional to the angler effort at the time of the sample.

[9] Including Saturdays and Sundays, and the 3 September Labor day holiday.

To obtain the estimates of the catch, harvest, and angler effort the following procedures were followed. Weighting was accomplished by:

c'_{hij} = weighted angler catch for angler j during day i within stratum h;

$$= \frac{\bar{x}_{hi}}{\bar{\bar{x}}_{h}} c_{hij} \quad ; \tag{35}$$

where:

c_{hij} = catch of angler j during day i within stratum h;

$\bar{x}_{hi}$ = mean angler count for day i within stratum h;

$$= \frac{\sum_{k=1}^{r_{hi}} x_{hik}}{r_{hi}} \quad ; \tag{36}$$

r_{hi} = the number of count samples within day i and stratum h;

x_{hik} = the number of anglers counted fishing during count k within day i and stratum h;

$\bar{\bar{x}}_{hi}$ = mean of mean angler count for stratum h;

$$= \frac{\sum_{i=1}^{d_{xh}} \bar{x}_{hi}}{d_{xh}} \quad ; \text{ and,} \tag{37}$$

d_{xh} = number of days sampled for counts within stratum h.

Then using the weighted catches the jackknife sample estimate of mean CPUE was obtained as follows:

$CPUE'^{*}_{hij}$ = the jackknifed weighted CPUE for angler j in day i within stratum h;

$$= \frac{\sum_{\substack{o=1 \\ o \neq j}}^{m_{hi}} c'_{hio}}{\sum_{\substack{o=1 \\ o \neq j}}^{m_{hi}} e_{hio}} ; \qquad (38)$$

where:

m_{hi} = number of anglers interviewed on day i within stratum h; and,

e_{hio} = un-weighted effort in hours expended by angler o within day i and stratum h

The jackknife mean CPUE for day i within stratum h was obtained by:

$$\overline{CPUE}'^{*}_{hi} = \frac{\sum_{j=1}^{m_{hi}} CPUE'^{*}_{hij}}{m_{hi}} . \qquad (39)$$

Then the bias correction (adapted from Efron 1982, equation 2.8, page 6) was performed:

$$\overline{CPUE}'^{*\dagger}_{hi} = [\, m_{hi} (\overline{CPUE}'_{hi} - \overline{CPUE}'^{*}_{hi}) \,] + [\, \overline{CPUE}'^{*}_{hi} \,] ; \qquad (40)^{10}$$

where:

$\overline{CPUE}'_{hi}$ = the standard weighted ratio estimator:

$$= \frac{\sum_{j=1}^{m_{hi}} c'_{hij}}{\sum_{j=1}^{m_{hi}} e_{hij}} . \qquad (41)$$

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[10] If the bias correction resulted in an mean value that was less then zero, then the unbiased corrected value was used in further calculations.

The bias-corrected weighted jackknife mean was averaged over all days sampled within stratum h:

$$\widehat{\overline{CPUE}}_h'^{*\dagger} = \frac{\sum_{i=1}^{d_h} \overline{CPUE}_{hi}'^{*\dagger}}{d_h} ; \quad (42)$$

where:

d_h = number of days sampled for interviews within stratum h

This estimated mean CPUE for each stratum was used to estimate the catch for the stratum by expansion:

$$\hat{C}_h = \hat{E}_h \widehat{\overline{CPUE}}_h'^{*\dagger} ; \quad (43)$$

where:

$\hat{E}_h$ = effort estimate for stratum h from angler counts;

$$= D_h H_h \bar{x}_h ; \quad (44)$$

D_h = number of days available for sampling in stratum h; and,

H_h = number of hours within each sampling day for stratum h.

The harvest for each stratum was estimated similarly by substituting the appropriate harvest statistics into equations (35) to (43), above.

The variance of the estimated catch for stratum h was obtained by the formula proposed by Goodman (1960) for the variance of a product of independent random variates:

$$\hat{V}[\hat{C}_h] = \hat{E}_h^2 \hat{V}[\widehat{\overline{CPUE}}_h'^{*\dagger}] + [\widehat{\overline{CPUE}}_h'^{*\dagger}]^2 \hat{V}[\hat{E}_h] - \hat{V}[\widehat{\overline{CPUE}}_h'^{*\dagger}] \hat{V}[\hat{E}_h] ; \quad (45)$$

where:

$\hat{V}[\overline{\hat{CPUE}}_h'^{*\dagger}]$ = estimated variance of the estimated mean bias-corrected weighted jackknife CPUE for stratum h, obtained by the two-stage variance equation (following the approach outlined by Cochran 1977), omitting the finite population correction (fpc) factor for the second stage units:;

$$= (1 - f_{1h}) \frac{s_{1h}^2}{d_h} + f_{1h} \sum_{i=1}^{d_h} \left\{ \frac{s_{2hi}^{2'*}}{d_h^2} \right\} ; \quad (46)$$

f_{1h} = sampling fraction for days (interview samples);

$$= \frac{d_h}{D_h} ; \quad (47)$$

s_{1h}^{2*} = the among day variance for the CPUE estimate;

$$= \frac{\sum_{i=1}^{d_h} (\overline{CPUE}_{hi}'^{*\dagger} - \overline{\hat{CPUE}}_h'^{*\dagger})^2}{d_h - 1} ; \quad (48)$$

$s_{2hi}^{2'*}$ = jackknife estimate of the variance for the jackknifed daily mean CPUE for day i within stratum h (adapted from Efron 1982, equation 3.2, page 13), note that the bias-corrected values for CPUE were <u>not</u> used in this calculation as bias-corrected CPUE's are not estimable for individual anglers;

$$= \frac{(m_{hi} - 1)}{m_{hi}} \sum_{j=1}^{m_{hi}} (\overline{CPUE}_{hij}'^{*} - \overline{CPUE}_{hi}'^{*})^2 ; \quad (49)$$

$\hat{V}[\hat{E}_h]$ = estimated variance of the angler effort estimate for stratum h, obtained by a two-stage estimation approach;

$$= (1 - f_{x1h})\ (D_h\ H_h)^2\ \frac{s^2_{x1h}}{d_{xh}} + f_{x1h}\ (D_h\ H_h)^2 \sum_{i=1}^{d_{xh}} \left\{ \frac{s^2_{x2hi}}{d^2_{xh}\ r_{hi}} \right\} ; \quad (50)$$

f_{x1h} = sampling fraction for days (count samples);

$$= \frac{d_{xh}}{D_h} ; \quad (51)$$

s^2_{x1h} = the among day variance for the effort estimate;

$$= \frac{\sum_{i=1}^{d_{xh}} (\bar{x}_{hi} - \bar{\bar{x}}_h)^2}{d_{xh} - 1} ; \text{ and,} \quad (52)$$

s^2_{x2hi} = the within day variance for the effort estimate;

$$= \frac{\sum_{k=1}^{r_{hi}} (x_{hik} - \bar{x}_{hi})^2}{r_{hi} - 1} . \quad (53)$$

Variance estimates for the estimated harvest were obtained by replacing the appropriate harvest statistics (h's and H's) for the catch statistics (c's and H's) in equations (45) through (49), above.

Total angler effort, catch, or harvest across all strata (or select combinations of strata) and the associated variances were obtained by the following equations:

$\hat{Y}$ = total estimated angler effort, catch, or harvest, where Y equals the parameter of interest (e.g., E, C, or H for effort, catch, and harvest, respectively);

$$= \sum_{h=1}^{s} \hat{Y}_h \qquad (54)$$

where:

s = number of strata to be combined;

$\hat{Y}_h$ = estimate for the parameter of interest in stratum *h*;

$\hat{V}[\hat{Y}]$ = variance estimate for the estimated total for the parameter of interest, assuming independence of the stratum estimates (see Kish 1965, equation 2.8.7, page 61);

$$= \sum_{h=1}^{s} \hat{V}[\hat{Y}_h]; \text{ and,} \qquad (55)$$

$\hat{V}[\hat{Y}_h]$ = variance estimate for the parameter of interest in stratum *h*.

Since our estimates of angler effort, catch, and harvest are estimates of totals, then standard errors (SE's) were obtained as follows:

$$\hat{SE}(\hat{Y}) = (\hat{V}[\hat{Y}])^{1/2} \qquad (56)$$

Equation (56) was also applied to the individual stratum estimates to obtain standard errors for the stratum estimates of effort, catch, and harvest.

The assumptions necessary for unbiased point and variance estimates obtained by the procedures outlined above are:

1. incompleted-trip angler catch and harvest rates, though probably biased, were assumed to provide an approximate estimate of completed-trip angler catch and harvest rates;

2. no significant fishing effort occurred during the hours not surveyed (i.e., between 2300 and 0800 each day);

3. catch and harvest were independent of duration of fishing trip (as per DiConstanzo 1956);

4. the angler count process was approximately instantaneous, or it was assumed that the creel clerk traveled substantially faster than anglers move about the fishery, or exit, or enter; and,

5. the among sampling period component of variation for catch and harvest rate was small in comparison to the among angler component and the among day component.

The last assumption, above, was necessary due to the inability to estimate the among sampling period variance component (within each sampled day and stratum). Regardless of the validity of assumption number 5, the variance estimates are biased negatively by an unknown amount (too small). The point estimates should be unbiased and unaffected by the validity of assumption 5.

However, assumption number 4 is undoubtedly invalid, in that the counts were conducted concurrently with interviews over a two hour period. During these count/interview samples some anglers entered the fishery and left the fishery (non-instantaneous count). The effect of the non-instantaneous nature of the counts would be to bias our point estimates of angler effort, catch, and harvest in an upward manner, in that anglers with longer trip duration would have a larger probability of being counted than anglers with short trip duration (Robson 1961). The degree of this bias is unknown.

CPUE and HPUE of anglers participating in the 1989 upper Chena River Arctic grayling fishery were estimated by the procedures noted below. The estimates obtained by these procedures are reflective of the individual rates experienced by anglers rather than the rates obtained by the harvest and effort estimation procedures (i.e., the jackknifed CPUE's and HPUE's used for expansion purposes).

To obtain the estimates of CPUE weighting was from the sample weights. This weighting procedure ensured that each angler's CPUE information was proportional to the angler effort at the time of the sample. The weighted CPUE for each angler was obtained as follows (using information from both completed and incompleted-trip interviews):

$$CPUE'_{hij} = w_{hi} \frac{c_{hij}}{e_{hij}} ; \qquad (57)$$

where:

w_{hi} = sample weight for day *i* within stratum *h*;

$$= \frac{\bar{x}_{hi}}{\bar{\bar{x}}_h} ; \quad (58)$$

$\bar{x}_{hi}$ = mean angler count for day *i* within stratum *h* from equation 36; and,

$\bar{\bar{x}}_h$ = mean of mean angler count for stratum *h* from equation 37.

The weighted mean CPUE was estimated for each sample as:

$$\overline{CPUE}'_{hi} = \frac{\sum_{j=1}^{m_{hi}} CPUE'_{hij}}{m_{hi}} ; \quad (59)$$

The stratum estimates of CPUE were obtained as a mean of mean weighted CPUE:

$$\overline{\overline{CPUE}}_h = \frac{\sum_{i=1}^{d_h} \overline{CPUE}'_{hi}}{d_h} \quad (60)$$

To obtain estimates of mean CPUE across all strata, or select combinations of strata, the individual stratum estimates of CPUE were weighted by the relative size of each stratum in terms of the estimated number of fishing trips (following the procedures explained in Cochran 1977, Equation 10.45, page 288), as follows:

$\hat{CPUE}$ = estimated mean CPUE across sampling strata;

$$= \sum_{h=1}^{s} \hat{W}_h \overline{\overline{CPUE}}_h ; \quad (61)$$

where:

$\hat{W}_h$ = estimated relative stratum weight of stratum h;

$$= \frac{\hat{A}_h}{\hat{A}} ; \quad (62)$$

$\hat{A}_h$ = estimated number of fishing trips within stratum h, obtained from the ratio of the angler effort estimate to the weighted mean effort expended by interviewed anglers who had completed their trips;

$$= \frac{\hat{E}_h}{\bar{e}'_{ch}} ; \quad (63)$$

$\hat{E}_h$ = angler effort estimate (in angler-hours) obtained by the procedures outlined for the estimation of angler effort, catch, and harvest, above;

$\bar{e}'_{ch}$ = mean of mean weighted angler effort for completed-trip anglers interviewed within stratum h;

$$= \frac{\sum_{i=1}^{d_h} \bar{e}'_{chi}}{d_h} ; \quad (64)$$

$\bar{e}'_{chi}$ = mean weighted angler effort for completed-trip anglers interviewed during day i within stratum h;

$$= \frac{\sum_{j=1}^{m_{hi}} e'_{chij}}{m_{hi}} ; \quad (65)$$

e'_{chij} = weighted angler effort for completed-trip angler j during day i within stratum h;

$$= w_{hi}\, e_{chij} \; ; \tag{66}$$

e_{chij} = effort in hours expended by completed-trip angler j within day i and stratum h; and

$\hat{A}$ = total estimated number of fishing trips;

$$= \sum_{h=1}^{s} \hat{A}_h \; . \tag{67}$$

HPUE estimates were obtained similarly by substituting the appropriate harvest statistics into equations (57) to (61).

The variance of the across stratum CPUE estimate was obtained by treating the estimated stratum weights as if they were constants (see Kish 1965, equations 2.8.5 and 2.8.7, pages 60 and 61), accordingly the variance estimate was only approximate:

$$\hat{V}[\hat{CPUE}] \approx \sum_{h=1}^{s} \hat{W}_h^2\, \hat{V}[\overline{CPUE}_h] \; ; \tag{68}$$

where:

$\hat{V}[\overline{CPUE}_h]$ = estimated variance of the stratum estimates of the mean of mean weighted CPUE, obtained by the usual two-stage equation (see Cochran 1977, equation 10.15, page 278), omitting the finite population correction (fpc) factor for the second stage units (i.e., the anglers interviewed):

$$= (1 - f_{1h}) \frac{s_{1h}^2}{d_h} + f_{1h} \sum_{i=1}^{d_h} \frac{s_{2hi}^2}{d_h^2 m_{hi}} \; ; \tag{69}$$

f_{1h} = sampling fraction for days from equation 47;

s_{1h}^2 = among day variance for the weighted CPUE;

$$= \frac{\sum_{i=1}^{d_h} (CPUE_{hi}' - \overline{CPUE_h}')^2}{d_h - 1} \text{ ; and,} \quad (70)$$

s_{2hi}^2 = among angler variance for the weighted CPUE;

$$= \frac{\sum_{j=1}^{m_{hi}} (CPUE_{hij}' - \overline{CPUE_{hi}}')^2}{m_{hi} - 1} . \quad (71)$$

Variance estimates for the estimated HPUE's were obtained similarly by substituting the appropriate harvest statistics into equations (68) through (71).

Since estimates of the variance of CPUE and HPUE are estimates of the estimated statistics, then standard errors (SE's) were obtained as follows:

$$\widehat{SE}(Y) = (\hat{V}[Y])^{1/2} \quad (72)$$

where:

Y = either CPUE or HPUE, as appropriate.

Equation (72) was also applied to the individual stratum estimates to obtain standard errors for the stratum estimates of CPUE or HPUE.

Results and Discussion

The upper Chena River Arctic grayling creel began on 19 May and continued through 13 September 1989. During this time, 120 angler counts were conducted on 101 days, of which 54 days were weekends or holidays and 47 days were weekdays (Table 12). Thirty-three percent of the sampling days occurred from 1100 to 1900 hours on weekends and holidays, 21% occurred from 0800 to 1100 hours and 1900 to 2300 hours on weekends and holidays, and 46% occurred from 0800 to 2300 hours on weekdays. The number of anglers counted on both weekends and weekdays peaked around 1400 hours (Figure 7). Thirty-five days were sampled in the May-June strata, 29 days were sampled in the July strata, and 37 days were sampled in the August-September strata.

Table 12. Angler catch and effort estimates for the upper Chena River Arctic grayling creel survey during the 19 May - 13 September 1989 period.

	Strata		Sampling Information[a]					Parameter Estimates[b]							
Temporal Component	Type of fishing day	Sampling Period	dc	D	H	di	m	$\bar{x}$	SE($\bar{x}$)	$\hat{E}$	SE($\hat{E}$)	$\hat{C}$	SE($\hat{C}$)	$\hat{H}$	SE($\hat{H}$)
May-June	Weekend-holiday	1100-1900	12	13	7	10	59	13.06	1.38	1,188	126	493	153	61	46
		0800-1100 & 1900-2300	8	13	8	5	29	4.69	1.15	488	120	527	226	279	201
	Weekday	0800-2300	15	30	15	12	58	4.87	0.84	2,190	380	1,809	901	444	262
	All days	All day	---	---	---	---	146	---	---	3,866	418	2,829	942	785	334
July	Weekend-holiday	1100-1900	10	11	7	10	75	11.95	0.72	920	55	475	115	96	48
		0800-1100 & 1900-2300	6	11	8	5	14	7.00	1.52	616	134	351	161	11	13
	Weekday	1100-1900	10	20	7	9	44	10.45	2.50	1,463	350	2,278	1,479	1,350	1,250
		0800-1100 & 1900-2300	3	20	8	3	10	11.67	5.69	1,867	911	1,931	1,100	478	475
	All days	All day	---	---	---	---	143	---	---	4,866	986	5,035	1,854	1,935	1,338
August-September	Weekend-holiday	1100-1900	11	13	7	9	32	6.14	0.78	558	71	314	122	30	24
		0800-1100 & 1900-2300	7	13	8	3	7	2.14	0.79	223	82	578	414	92	149
	Weekday	1100-1900	13	31	7	9	26	4.46	0.88	968	191	605	443	482	437
		0800-1100 & 1900-2300	6	31	8	3	7	3.50	2.11	868	523	918	959	0	0
	All days	All day	---	---	---	---	72	---	---	2,617	567	2,414	1,141	605	462

(continued)

Table 12. (page 2 of 2).

Temporal Component	Strata: Type of fishing day	Strata: Sampling Period	Sampling Information[a]: dc	D	H	di	m	$\bar{x}$	SE(x)	Parameter Estimates[b]: $\hat{E}$	SE(E)	$\hat{C}$	SE(C)	$\hat{H}$	SE(H)
All season	Weekend-holiday	All day	---	---	---	---	216	---	---	3,993	251	2,738	547	570	260
	Weekday	All day	---	---	---	---	145	---	---	7,356	1,186	7,540	2,307	2,755	1,431
All season	All days	All day	---	---	---	---	361	---	---	11,349	1,212	10,278	2,372	3,325	1,455

[a] dc = number of days sampled for angler counts (all days sampled)
D = total number of days available for sampling
H = hours available for sampling within each day
di = number of days sampled for angler interviews (all days sampled minus sampled days in which no anglers interviewed)
m = total number of anglers interviewed.

[b] $\bar{x}$ = mean of means-angler count (mean within day and then between day)
$SE(\bar{x})$ = standard error of $\bar{x}$
$\hat{E}$ = estimated angler effort in angler-hours
$SE(\hat{E})$ = standard error of $\hat{E}$
$\hat{C}$ = estimated catch of Arctic grayling
$SE(\hat{C})$ = standard error of $\hat{C}$
$\hat{H}$ = estimated harvest of Arctic grayling
$SE(\hat{H})$ = standard error of $\hat{H}$.

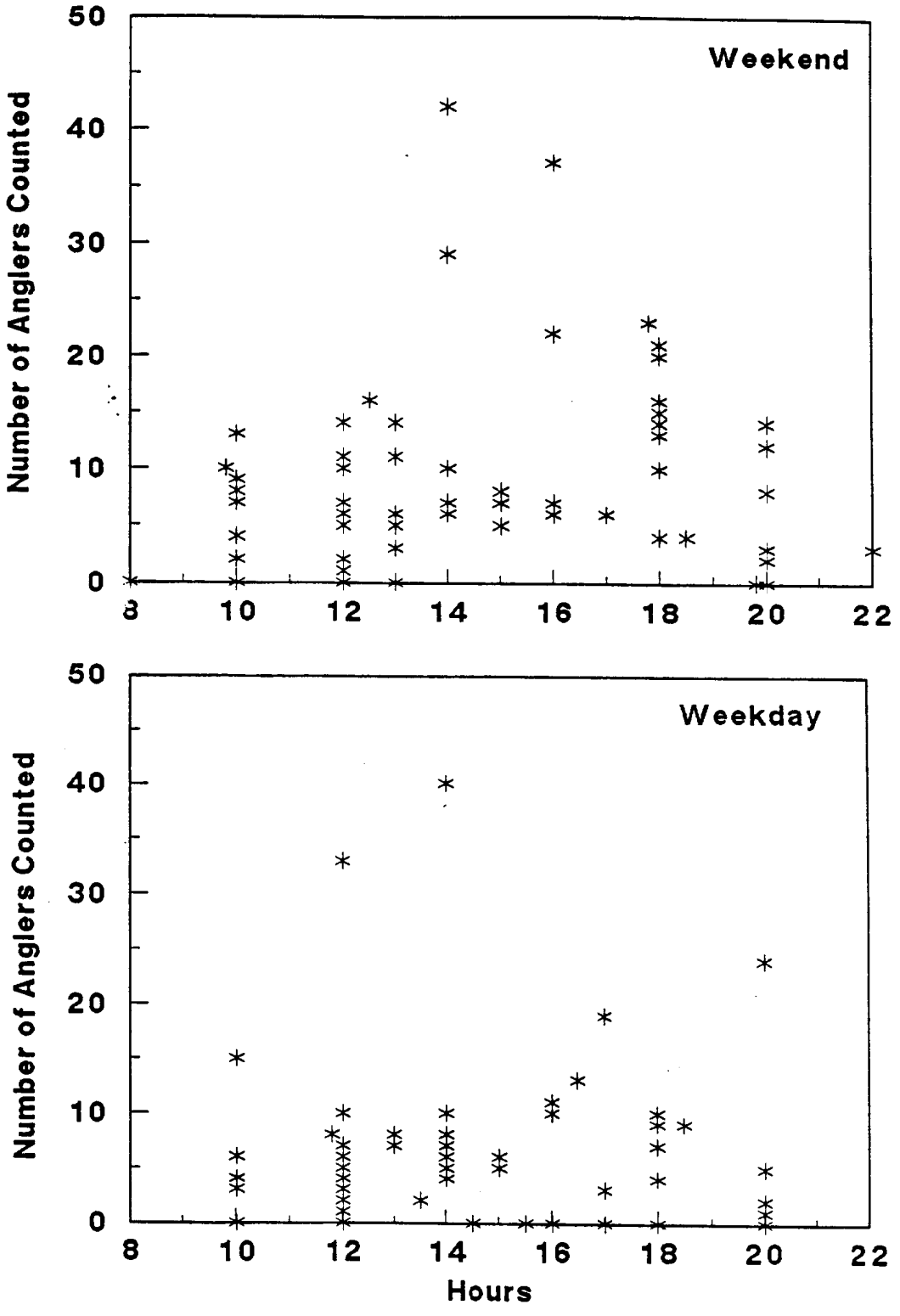

Figure 7. Distribution of angler counts by hour among strata, upper Chena River, 1989.

A total of 361 interviews were conducted, of which 216 (60%) occurred on weekends and holidays (Table 12). The majority (46%) of interviews were obtained on weekends and holidays from 1100-1900 hours. In the May-June strata, 146 anglers were interviewed, in the July strata 143 anglers were interviewed, and in the August-September strata, 72 anglers were interviewed.

The highest mean angler count was 13.06 (SE = 1.38) and occurred early in the season, during the May-June strata (Table 12).

Total angler effort was estimated to be 11,349 hours (SE = 1,212). The greatest angler effort (4,866 hours, or 43%) occurred in the July strata.

Total catch was estimated to be 10,278 (SE = 2,372) Arctic grayling. Total harvest was estimated to be 3,325 (SE = 1,455) Arctic grayling, with the majority (58%) of the harvest occurring in the July strata (Table 12).

The legal-sized harvest distribution of Arctic grayling among anglers who had completed fishing at the time of the interview shows that the majority of the anglers harvested zero Arctic grayling (Figure 8). Most of the rest of the anglers who had harvested Arctic grayling and who had completed fishing had taken two Arctic grayling. One individual had violated state law by retaining 16 Arctic grayling. This suggests that a reduction in the bag limit from five fish to two fish per day would potentially affect few anglers complying with state law.

Mean CPUE for the season was estimated at 0.81 (SE = 0.14), with the highest CPUE occurring within the August-September strata (3.42, SE = 1.61). Mean HPUE for the season was 0.21 (SE = 0.07), with the greatest HPUE occurring within the August-September strata (1.24, SE = 1.24; Table 13).

Total fishing trips were estimated at 5,186 for the upper Chena River fishery. Most (56%) occurred in July (Table 13).

Age data were collected from 60 Arctic grayling examined in the harvest from the upper Chena River. Age at harvest ranged from 3 to 9 years (Table 14). Age 5 Arctic grayling made up 30% of the harvest while 27% were age 4 and 25% were age 6. Mean fork length for the entire sampled harvest sample was 295 mm, which was approximately equal to an age 5 Arctic grayling. Quality size Arctic grayling made up the majority of the sampled harvest at 52%, followed by stock size Arctic grayling at 30%, and preferred size at 18%. There were no Arctic grayling in the memorable or trophy size classes.

Younger fish have comprised a greater proportion of the harvest sample in 1988 and 1989 than observed in 1986 and 1987 (Figure 9). The 1989 harvest sample consisted of a greater proportion of age 4 fish than observed in years 1986-1988. Age 6 and age 7 Arctic grayling comprised the greatest proportions of the harvest sample in 1986 and 1987, respectively, while age 5 fish comprised the greatest proportion in 1988 and 1989.

The majority of the anglers interviewed fished from shore (87%). Most anglers utilizing the upper Chena River Arctic grayling fishery in 1989 were male

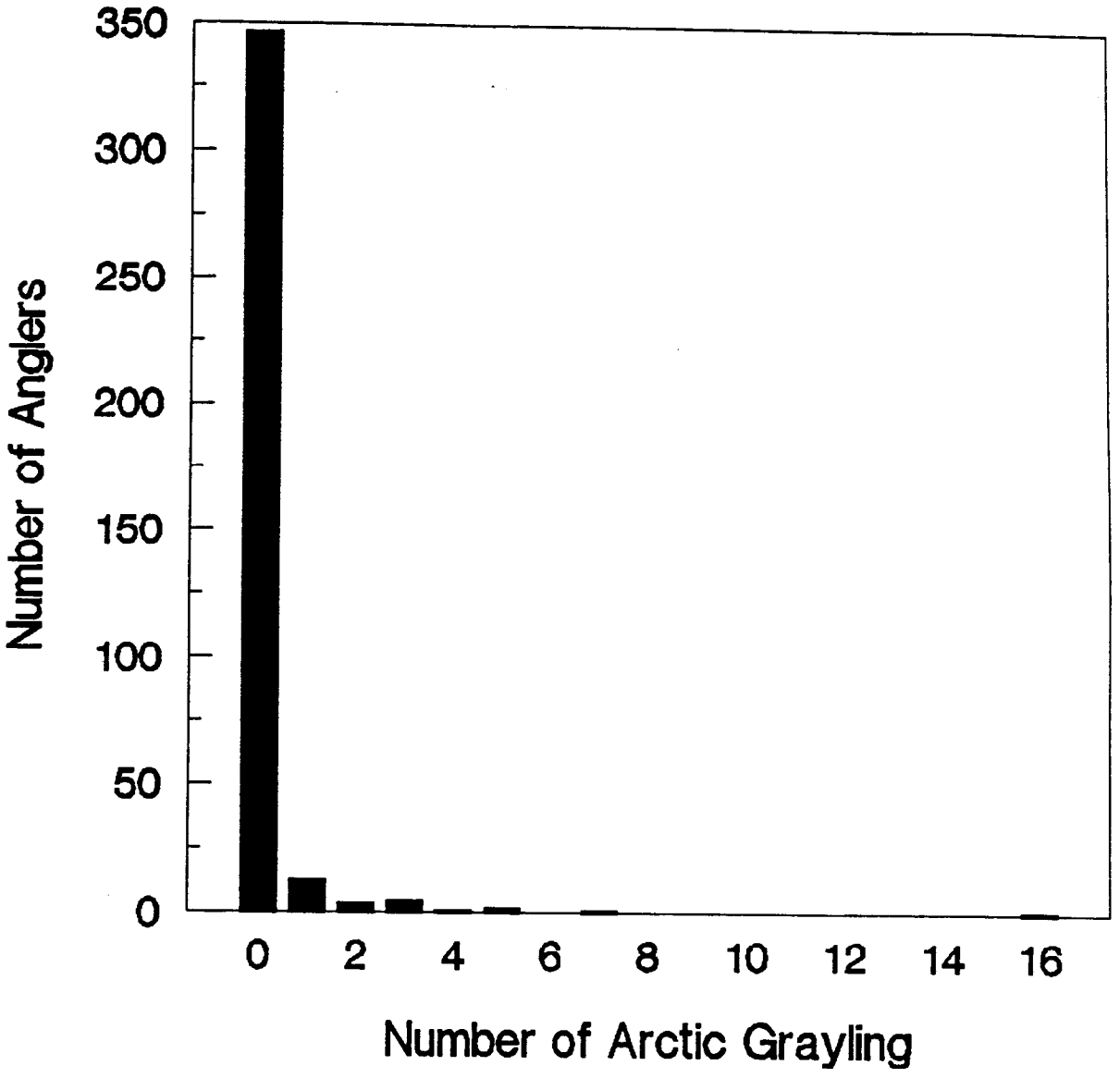

Figure 8. Distribution of Arctic grayling harvest among anglers interviewed at the upper Chena River, Tanana River drainage, Alaska, 1989.

Table 13. Angler CPUE and HPUE estimates for the upper Chena River Arctic grayling creel survey during the 19 May - 13 September 1989 period.

Strata			Sampling Information[a]			Parameter Estimates[b]				
			d	D	m	CPUE	SE(CPUE)	HPUE	SE(HPUE)	$\hat{A}$
May-June	Weekend-holiday	1100-1900	10	13	59	0.34	0.10	0.05	0.04	617
		0800-1100 & 1900-2300	5	13	29	0.88	0.39	0.53	0.39	213
	Weekday	0800-2300	12	30	58	0.83	0.36	0.15	0.08	825
	All days	All day	---	---	146	0.66	0.19	0.16	0.07	1,655
July	Weekend-holiday	1100-1900	10	11	75	0.39	0.10	0.06	0.03	481
		0800-1100 & 1900-2300	5	11	14	0.45	0.22	0.02	0.02	408
	Weekday	1100-1900	9	20	44	1.51	0.67	0.45	0.38	613
		0800-1100 & 1900-2300	3	20	10	0.8900	0.35	0.18	0.18	1,320
	All days	All day	---	---	143	0.88	0.22	0.19	0.12	2,822
August-September	Weekend-holiday	1100-1900	9	13	32	0.44	0.16	0.03	0.02	173
		0800-1100 & 1900-2300	3	13	7	3.42	1.61	1.24	1.24	87
	Weekday	1100-1900	9	31	26	0.56	0.45	0.50	0.45	262
		0800-1100 & 1900-2300	3	31	7	0.69	0.75	0.00	0.00	187
	All days	All day	---	---	72	0.92	0.33	0.34	0.23	709
All Season	All days	All day	---	---	361	0.81	0.14	0.21	0.07	5,186

[a] d = number of days sampled for angler interviews
D = total number of days available for sampling
m = total number of anglers interviewed.

[b] CPUE = estimated catch per unit effort
SE(CPUE) = standard error of CPUE
HPUE = estimated harvest per unit effort
SE(HPUE) = standard error of HPUE.

Table 14. Estimates of the contributions of each age class, mean fork length (mm) at age, and Relative Stock Density (RSD) of Arctic grayling in the harvest sample from the upper Chena River, Tanana River drainage, Alaska, 1989.

	Age Composition			Fork Length[a]		Relative Stock Density (RSD)				
Age	n	%	SE (%)	Mean	SE	Category	Range	n	%	SE (%)
3	2	3	2	248	25	Stock	150-269	18	30	6
4	16	27	6	257	16	Quality	270-339	32	52	6
5	18	30	6	295	23	Preferred	340-449	11	18	5
6	15	25	6	304	28	Memorable	450-559	0	0	--
7	4	7	3	337	16	Trophy	750-up	0	0	--
8	4	7	3	358	15					
9	1	1	--	362	--	Total		61	100	
Total	60[b]	100		295	38					

[a] Fork length is in millimeters (mm).
[b] One fish was not aged due to scale regeneration.

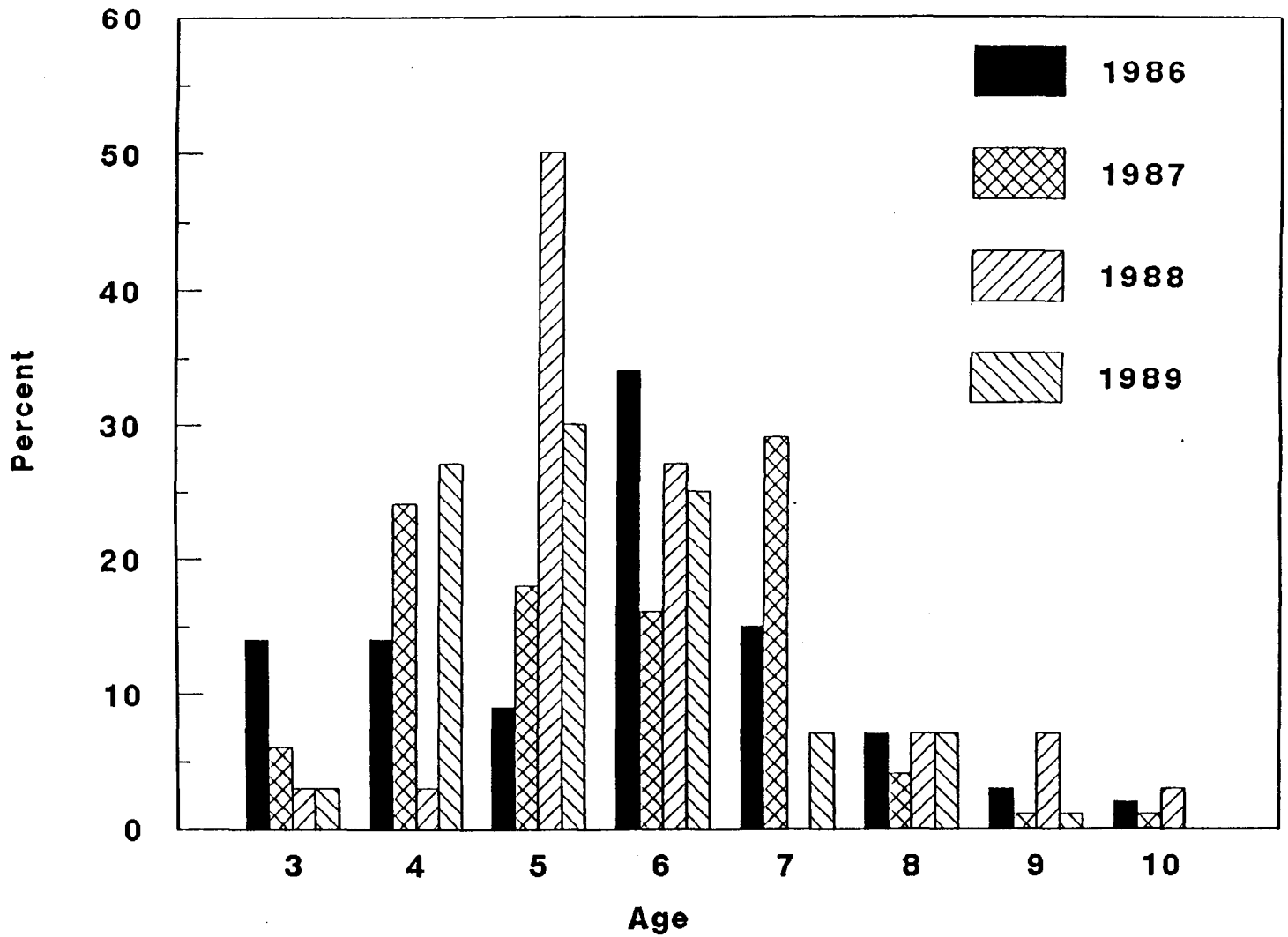

Figure 9. Age composition estimates of Arctic grayling in the harvest sample from the upper Chena River drainage, Alaska, 1986-1989.

(81%), adult (90%), residents of the State of Alaska (77%), and live in Fairbanks-North Pole area (68%; Table 15). Non-residents made up 19% of the anglers interviewed while 4% were military personnel. Thirty-two percent of anglers interviewed were tourists. The most popular terminal gear type was spinners (67%), followed by flies (31%).

Angler demographics in 1989 were similar to those observed in 1986-1988, except in regards to area of residence. Since 1986, increasing proportions of anglers fishing the upper Chena River have been tourists and non-locals (Table 16). The proportion of anglers who are military personnel has decreased in 1989 compared to prior years.

Anglers gave the upper Chena River Arctic grayling fishery a median rating of 4.00, which is a poor rating (Table 17). Of these anglers, 5% rated the fishery as excellent, 20% as good, 23% as fair, and 52% as poor. The majority of the anglers interviewed approved of the following: a 12 inch minimum length limit for Arctic grayling (88%); a no-bait restriction on the upper Chena River (86%); catch-and-release Arctic grayling fishing until the first Saturday in June (83%); and a catch-and-release only section for the upper Chena River (75%).

Angler opinions in 1989 differed from those in prior years (Table 18). Approval of the 12 inch minimum length limit and restriction of bait has increased since 1987. Approval of catch and release seasons and areas in 1989 has not significantly changed from that in 1988, but is greater than that expressed in 1986 and 1987. Fishing quality ratings have deteriorated since 1986.

CHAPTER 3 - LOWER CHENA RIVER CHINOOK SALMON FISHERY

Introduction

The lower 72 km of the Chena River supports a chinook salmon recreational fishery (Figure 10). Public access to the fishery is available at several locations from Pike's Landing (river kilometer 3.2) to the Chena River Park State Recreational Area (river kilometer 67). Annual sport harvest has been estimated by the statewide postal survey beginning in 1977 (Mills 1979-1989).

The lower Chena River creel program began in 1987 as a result of regulatory action which increased the area open to sport fishing. An additional 42 river kilometers were opened between the confluence of the little Chena River upstream to the Moose Creek Dam site (Figure 10). A significant increase in fishing effort resulted. In 1987, the objectives of the creel survey were to estimate CPUE and HPUE. These objectives were expanded in 1988 to include angler effort, catch and harvest estimates.

The specific objectives of the lower Chena River creel survey in 1989 were to:

1) estimate the amount angler-effort expended at the lower Chena River;

Table 15. Demographic profile of anglers interviewed at the upper Chena River, Tanana River drainage, Alaska, 1989.

Angler Characteristic	n[a]	%	SE (%)	Angler Characteristic	n[a]	%	SE (%)
Total Number of Interviews[b]	438	--	--	Local[c]	290	68	2
				Non-local	137	32	2
Shore Anglers	377	--	--				
Boat Anglers	54	--	--	Tourist	136	32	2
				Other	291	68	2
Male	354	81	2				
Female	83	19	2	Gear Type:			
				Spinners	265	67	2
Adult	388	90	1	Flies	122	31	2
Youth	45	10	1	Jigs	3	--	--
				Bait	8	2	1
Resident	328	77	2				
Non-Resident	80	19	2				
Military	19	4	1				

[a] Number of anglers in the categories will not always equal the total number of interviews because angler demographics were not marked down for all the anglers interviewed.

[b] Includes both complete- and incomplete-trip angler interviews combined.

[c] Local and non-local category includes Alaska residents only. Local category are anglers from the Fairbanks-North Pole area.

Table 16. Percent of categories[a] representing demographic profiles of anglers interviewed at the upper Chena River, Tanana River drainage, Alaska, 1986-1989.[c]

Angler characteristic	1989[b]	1988[b,d]	1987[b,e]	1986[e]
Number of interviews	438	325	356	338
Male	81 (2)	75 (2)	79 (2)	80 (2)
Adult	90 (1)	80 (1)	80 (2)	81 (2)
Resident	77 (2)	70 (3)	84 (2)	86 (2)
Nonresident	19 (2)	24 (2)	16 (2)	14 (2)
Military	4 (1)	7 (1)	9 (2)	6 (1)
Local	68 (2)	82 (3)	79 (2)	82 (2)
Tourist	32 (2)	18 (2)	16 (2)	9 (1)
Primary Gear	spinners	spinners	spinners	spinners

[a] Standard errors in parentheses.

[b] Restrictive regulations in effect.

[c] Percent calculated by dividing the total number of respondents to that question by the number in the category.

[d] Baker 1989

[e] Baker 1988

Table 17. Opinions of anglers interviewed at the upper Chena River, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%[a]	SE(%)
1. How would you rate the quality of Arctic grayling fishing at the upper Chena River this year?	Excellent (1)	13	5	4
	Good (2)	51	20	3
	Fair (3)	58	23	3
	Poor (4)	128	52	3
	No opinion (5)	184		
	Total	434	100	
	Mean Rating =	3.22		
	Median Rating =	4.00		
2. What is your opinion of a 12 inch minimum length limit for Arctic grayling in the upper Chena River?	Approve	314	88	2
	Disapprove	42	12	2
	No Opinion	67	--	--
	Total	423	100	
3. What is your opinion of restricting the use of bait in the upper Chena River (only artificial flies and lures may be used)?	Approve	294	86	2
	Disapprove	49	14	2
	No Opinion	86	--	--
	Total	429	100	
4. What is your opinion of catch and release only for Arctic grayling in the upper Chena River until the first Saturday in June?	Approve	295	83	2
	Disapprove	60	17	2
	No Opinion	71	--	--
	Total	426	100	
5. What is your opinion of designating the section of the upper Chena River from the confluence of the South Fork upstream to the 1st bridge as catch and release fishing only for Arctic grayling?	Approve	263	75	2
	Disapprove	88	25	2
	No Opinion	75	--	--
	Total	426	100	

[a] Percentages are calculated for anglers with opinions only and do not take into account anglers in the no-opinion category.

Table 18. Percent approval[a] and mean rating of the quality of fishing, based on opinions of anglers interviewed at the upper Chena River, Tanana River drainage, Alaska, 1986-1989.

Question	1989[b]	1988[b,c]	1987[b,d]	1986[d]
Minimum 12 inch length limit	88 (2)	84 (3)	73 (3)	--
Restriction of bait	86 (2)	76 (3)	70 (3)	--
Catch and release only until June	83 (2)	86 (2)	64 (3)	--
Section of river catch and release	75 (2)	77 (3)	62 (3)	55 (4)
Mean quality rating	3.22	3.06	2.91	2.27

[a] Standard errors in parentheses.

[b] Restrictive regulations in effect.

[c] Baker 1989

[d] Baker 1988

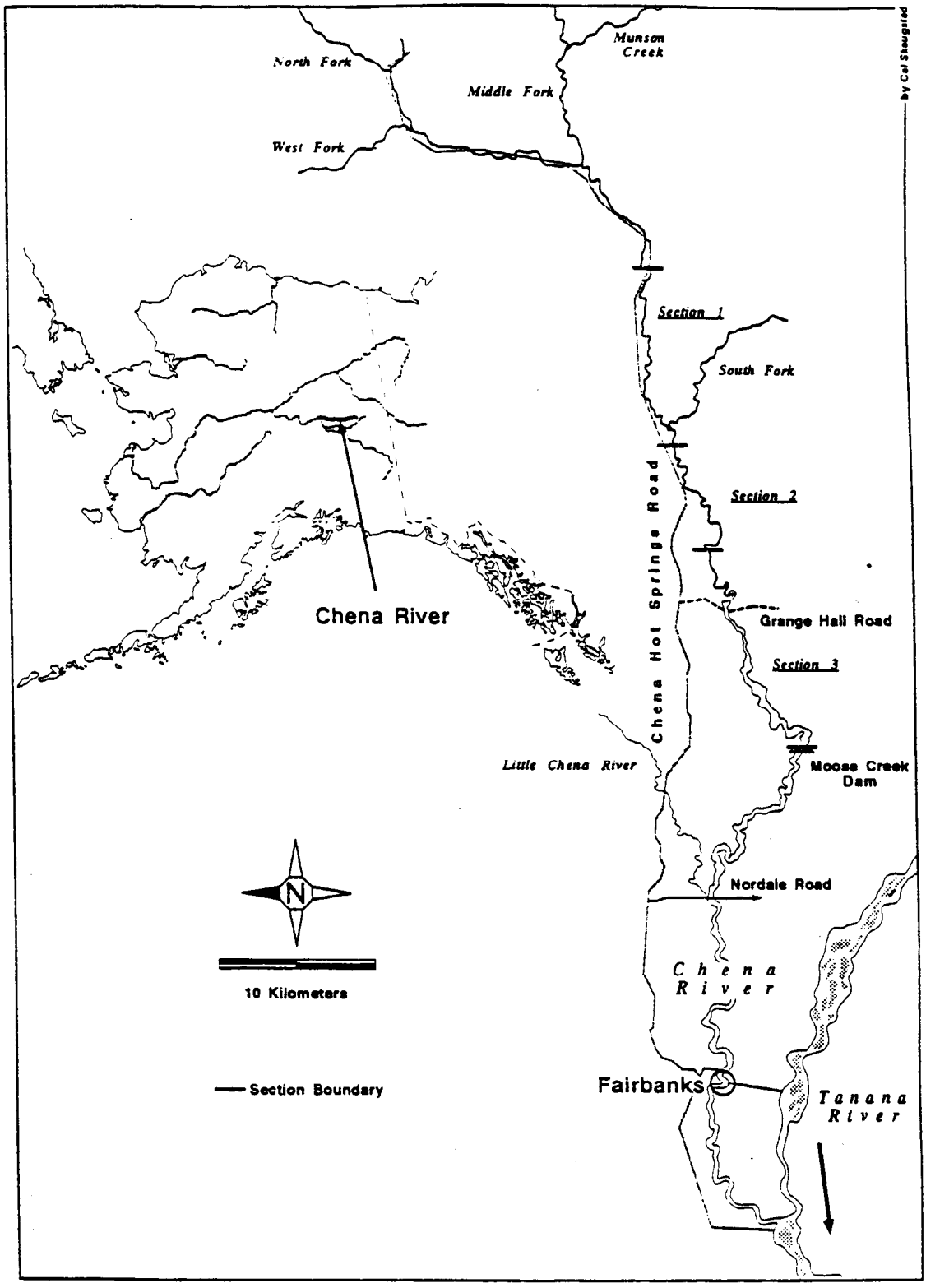

Figure 10. Map of the lower Chena River, Tanana River drainage, Alaska.

2) estimate CPUE, HPUE, catch, and harvest for chinook salmon at the lower Chena River;

3) estimate the percent composition of angler demographics for the lower Chena River that include: a) male/female, b) adult/youth, c) resident/non-resident/military, d) local/ non-local, e) tourist/other, and f) terminal fishing gear (spinner/bait/flies/jigs/trolling/ spear/bow and arrow);

4) estimate the percent response (opinions) to questions asked anglers at the lower Chena River; and,

5) estimate the rating by anglers of the quality of fishing.

Methods

The lower Chena River chinook salmon fishery occurred primarily in two areas: Area 1 - from the Fort Wainwright boat launch to the Nordale Road Bridge; and Area 2 - 2 km below the Moose Creek Dam Site upstream to the dam site (Figure 10). Both areas were creel surveyed with a roving harvest survey. The surveys were conducted during July, which is the time most chinook salmon arrive in the fishery. Sampling during July was stratified into (1) weekdays, and (2) weekends/holidays. The fishing day was defined to occur from 0600 hours to 2400 hours each day.

Sampling effort was optimally allocated based on catch and effort - as fishing effort increased during the peak of the run, so did sampling effort. Sampling effort was equally divided between the two access areas, and between weekends and weekdays. A total of 20 sample periods was desired. A sample period consisted of six consecutive hours; a count was conducted during each hour. The starting time was randomly chosen within the defined fishing day. Four hours were spent at Area 1 and two hours were spent at Area 2. Thus, allocation of sampling effort to Area 1 consisted of 20 periods, each four hours long, and allocation to Area 2 was 20 periods, each two hours long. Total desired counts were 120 (20 periods x six hours). Ten periods were allocated to weekends, and 10 were allocated to weekdays, grouped around the peak of the run.

The sampling procedure for Area 1 started with the creel clerk putting the boat in at Fort Wainwright. The clerk would make an angler count by driving the boat from the boat launch upstream to Nordale Road Bridge. The clerk would then drive the boat downstream to make a second count. Those anglers who had not yet completed fishing were given post cards to mail in to ADFG upon completion of their fishing trip. Returned post cards were intended to augment the number of completed-trip interviews. About the same number of unsuccessful anglers returned cards as those who were successful, so any bias associated with this method is assumed to be small. Further, the number of cards returned was small.

The sampling procedure for Area 2 consisted of the creel clerk conducting an angler count by driving a boat downstream from the dam site two river

kilometers. The clerk would then return to the dam site to interview anglers in the area. The clerk would make a second angler count during the middle of sample period and finish the sample period by interviewing anglers near the dam site.

A roving-type creel survey (Neuhold and Lu 1957) was used to obtain angler, effort, catch, and harvest for the lower Chena River chinook salmon fishery. The fishery was sampled using a stratified multi-stage sample survey. Strata were defined as follows:

1. 7-21 July, weekdays[11], Area 1;
2. 7-21 July, weekdays, Area 2;
3. 22-30 July, weekend-holidays[12], Area 1; and,
4. 22-30 July, weekend-holidays, Area 2.

Within each stratum days were sampled at random and represent the first stage of sampling. Within each sampled day, sample periods were selected at random from the available hours in each sampling day. In general only one sample period per day within a stratum was selected for surveying. Accordingly, although the sample period truly represented the second stage of sampling, it was not treated as such (since the among sampling period component of variance could not be consistently estimated). Within each stratum, on each selected day, the anglers interviewed represented the second sampling stage for catch and harvest rate calculations. The counts conducted within each stratum on each selected day were treated as the second sampling stage for angler effort estimation.

A review of the data collected during 1989 indicated that during some sampling periods no anglers were interviewed, however anglers were fishing (i.e., count greater than zero). Accordingly, the approach used to obtain catch and harvest estimates was to obtain stratum estimates of angler effort, catch and harvest rates, i.e., CPUE and HPUE; and then to multiply the CPUE and HPUE stratum estimates by the stratum angler effort estimates to obtain the catch and harvest stratum estimates, respectively.

Both completed-trip and incompleted-trip angler interviews were used to estimate the catch and harvest rates for expansion purposes due to the low number of completed-trip interviews.

The CPUE and HPUE estimates were obtained by the jackknife estimation approach (Efron 1982). The jackknife approach for estimating CPUE and HPUE was used since most other estimators are known to be biased (for use as ratio estimators, i.e., for expansion), and the jackknife estimate has been shown to be less biased and procedures exist for correcting this bias (see Cochran 1977, section 6.15, pages 174-177; and Smith 1980). Prior to applying the jackknife procedure each angler's catch and harvest was weighted by the relative numbers of anglers utilizing the fishery during the interview period (as measured from the angler count). This weighting procedure ensures that

[11] Including Mondays through Fridays.

[12] Including Saturdays and Sundays.

each sample period's interview information was proportional to the angler effort at the time of the sample.

To obtain the estimates of the catch, harvest, and angler effort the procedures outlined in Chapter 2, using equations 35-56, were followed.

The assumptions necessary for unbiased point and variance estimates obtained by the procedures outlined in Chapter 2, equations 35-56 are:

1. incompleted-trip angler catch and harvest rates, though probably biased, were assumed to provide an approximate estimate of completed-trip angler catch and harvest rates;

2. no significant fishing effort occurred during the hours not surveyed (i.e., between 2400 and 0600 each day);

3. catch and harvest were independent of duration of fishing trip (as per DiConstanzo 1956);

4. the angler count process was approximately instantaneous, or we assume that the creel clerk traveled substantially faster than anglers move about the fishery, or exit, or enter; and,

5. within day variance was small, and variance estimated is a minimum.

Assumption number 4 is probably valid, in that counts were conducted by technicians in a boat, who undoubtedly traveled faster than actively fishing anglers.

CPUE and HPUE of anglers participating in the 1989 lower Chena River chinook salmon fishery were estimated by the procedures outlined in Chapter 2, equations 57-72.

Results and Discussion

The lower Chena River harvest survey was conducted from 7 July through 30 July 1989. There were 15 sample periods in Area 1 and 15 sample periods in Area 2, five less than desired for each area (Table 19). Sample periods were less than expected because of run timing characteristics of the chinook salmon in the lower Chena River in 1989. Arrival of chinook salmon in the fishery was about 10 days later, and more closely aggregated about the peak, than expected, thus shortening available sampling time. Forty-six percent of the sampling effort occurred during the peak of the run (22-30 July). A total of 14 days were sampled on weekends and 16 days were sampled on weekdays. The number of anglers counted on both weekends and weekdays tended to increase as the fishing day progressed, with peak counts occurring around 2000 hours (Figure 11). This means that the assumption of small within day variation was violated. In the future, this survey should be stratified by time of day to avoid biases associated with within day variability in anglers fishing.

Table 19. Angler catch and effort estimates for the lower Chena River chinook salmon creel survey during the 7-30 July 1989 period.

Strata			Sampling Information[a]					Parameter Estimates[b]							
Site	Temporal Component	Type of fishing day	dc	D	H	di	m	$\bar{x}$	SE($\bar{x}$)	$\hat{E}$	SE($\hat{E}$)	$\hat{C}$	SE($\hat{C}$)	$\hat{H}$	SE($\hat{H}$)
Dam Site	7-21 July	Weekend-holiday	3	4	18	2	12	3.67	1.39	264	100	274	251	143	124
		Weekday	5	11	18	4	26	4.10	1.50	812	296	236	174	118	74
	22-30 July	Weekend-holiday	4	4	18	3	30	8.50	0.77	612	56	57	34	57	34
		Weekday	3	5	18	1	6	1.00	1.00	90	90	31	31	15	15
	7-30 July	All days	15	24	---	10	74	---	---	1,778	330	597	308	333	149
Between Wainwright and Nordale	7-21 July	Weekend-holiday	3	4	18	3	29	17.50	3.36	1,260	242	219	82	137	60
		Weekday	5	11	18	4	30	6.00	1.90	1,188	377	249	160	204	155
	22-30 July	Weekend-holiday	4	4	18	3	18	4.58	0.41	330	29	11	12	11	12
		Weekday	3	5	18	3	18	4.25	2.15	382	194	0	0	0	0
	7-30 July	All days	15	24	---	13	95	---	---	3,160	489	479	181	352	167
Both Sites	7-21 July	All days	---	---	---	---	97	---	---	3,524	546	978	354	602	221
	22-30 July	All days	---	---	---	---	72	---	---	1,414	223	99	47	83	39
	7-30 July	All days	---	---	---	---	169	---	---	4,938	590	1,077	357	685	224

[a] dc = number of days sampled for angler counts (all days sampled)
D = total number of days available for sampling
H = hours available for sampling within each day
di = number of days sampled for angler interviews (all days sampled minus sampled days in which no anglers interviewed)
m = total number of anglers interviewed.

[b] $\bar{x}$ = mean of means-angler count (mean within day and then between day)
SE($\bar{x}$) = standard error of $\bar{x}$
$\hat{E}$ = estimated angler effort in angler-hours
SE($\hat{E}$) = standard error of $\hat{E}$
$\hat{C}$ = estimated catch of chinook salmon
SE($\hat{C}$) = standard error of $\hat{C}$
$\hat{H}$ = estimated harvest of chinook salmon
SE($\hat{H}$) = standard error of $\hat{H}$.

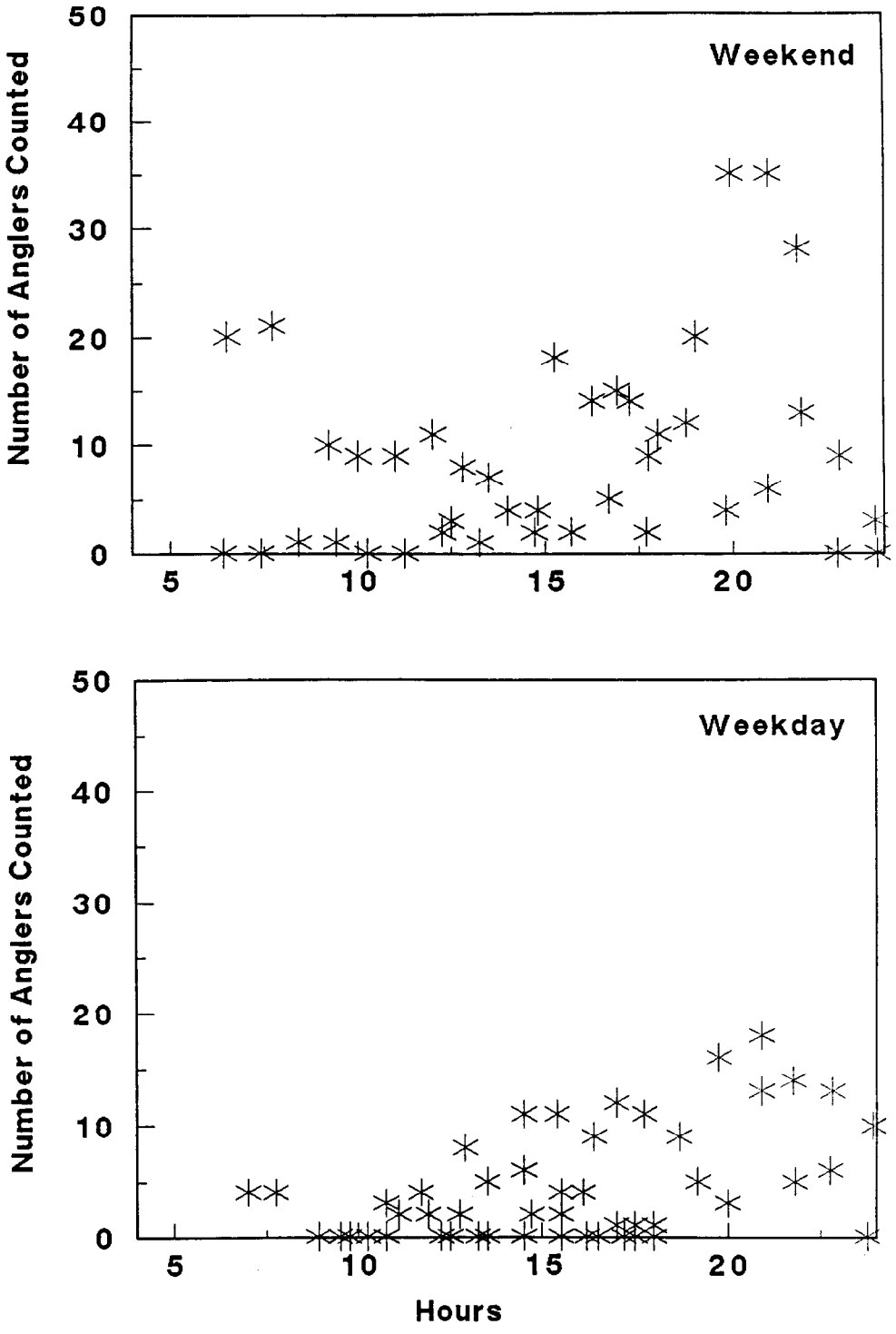

Figure 11. Distribution of angler counts by hour among strata, lower Chena River, 1989.

A total of 169 anglers were interviewed, of which 72 (43%) interviews occurred during the peak of the run; 89 (53%) interviews were conducted on weekends (Table 19). Seventy-four interviews (44%) were conducted at the dam site, which received only 33% of the sampling effort (two hours out of six hours in the sample period). Of those anglers interviewed, 133 were given post cards, and 35 cards (24%) were returned. Anglers returning post cards reported keeping 15 chinook salmon.

The highest mean angler count was 17.50 (SE = 3.36) and occurred on a weekend, between Fort Wainwright and Nordale Road, and prior to the peak of the run (Table 19).

Total angler effort was estimated at 4,938 hours (SE = 590; Table 19). Total catch was estimated to be 1,077 (SE = 357) chinook salmon. Total harvest was estimated at 685 (SE = 224) chinook salmon, with the harvest evenly divided between the dam site (49%) and the river section between Fort Wainwright and Nordale Road (51%; Table 19). Only 12% of the harvest occurred during the peak of the run.

Mean CPUE for the fishery was estimated at 0.21 (SE = 0.07). Mean HPUE for the fishery was estimated at 0.15 (SE = 0.06; Table 20). Total estimated number of fishing trips was 1,140 for the lower Chena River fishery. The greatest percentage (60%) of estimated fishing trips occurred between the boat ramp at Fort Wainwright and Nordale Road.

Anglers utilizing the lower Chena River chinook salmon fishery were primarily males (87%), adults (89%), and used spinners as their terminal angling gear (94%; Table 21). Thirty-one percent of the anglers were military personnel, 10% were non-resident, and 59% were residents of the State of Alaska. Of the anglers that were residents or military, 89% percent were from the Fairbanks-North Pole area. Only 7% of all the anglers interviewed were tourists. The proportion of non-local and tourist anglers in 1989 was slightly greater (9% and 6%, respectively) than that observed in 1988.

The majority of the anglers interviewed were asked questions relating to management and quality of the lower Chena River chinook salmon fishery. The anglers gave the fishery a median rating of 1, which is excellent (Table 22). Of the anglers interviewed, 50% rated the fishing excellent, 18% rated it good, 28% rated it fair, and 4% rated it poor. The fishery rating in 1989 was substantially better than that given in 1988 (median rating of 3, which is fair, Baker 1989). Ninety-nine percent of the anglers interviewed knew the bag limit. Ninety-two percent thought public boat access was adequate. Ninety percent approved of using emergency regulations and season closures to manage the fishery. Most (98%) approved of stocking chinook salmon in the lower Chena River. Angler attitudes in 1989 were similar to those in 1988.

In the two areas, chinook salmon harvest was estimated to be 685. This estimate should be considered a minimum estimate for the lower Chena River because some fishing was known to occur outside the sample areas. However, the amount of fishing that occurred outside the sample areas was considered slight. Spot checks were made during the creel survey in areas outside Areas 1 and 2 and very little fishing occurred in these other areas. The harvest

Table 20. Angler CPUE and HPUE estimates for the lower Chena River chinook salmon creel survey during the 7-30 July 1989 period.

Strata			Sampling Information[a] d	D	m	Parameter Estimates[b] CPUE	SE(CPUE)	HPUE	SE(HPUE)	$\hat{A}$
Dam Site	7-21 July	Weekend-holiday	2	4	12	0.57	0.53	0.30	0.26	100
		Weekday	4	11	26	0.31	0.17	0.21	0.12	208
	22-30 July	Weekend-holiday	3	4	30	0.14	0.12	0.14	0.12	143
		Weekday	1	5	6	0.22	0.06	0.11	0.05	10
	7-30 July	All days	---	---	74	0.31	0.14	0.21	0.09	461
Between Wainwright and Nordale	7-21 July	Weekend-holiday	3	4	29	0.10	0.05	0.06	0.04	205
		Weekday	4	11	30	0.22	0.15	0.20	0.16	334
	22-30 July	Weekend-holiday	3	4	18	0.02	0.02	0.02	0.02	64
		Weekday	3	5	18	0.00	0.00	0.00	0.00	76
	7-30 July	All days	---	---	95	0.14	0.08	0.12	0.08	679
Both Sites	7-21 July	All days	---	---	97	0.25	0.10	0.18	0.08	847
	22-30 July	All days	---	---	72	0.08	0.07	0.08	0.06	293
	7-30 July	All days	---	---	169	0.21	0.07	0.15	0.06	1,140

[a] d = number of days sampled for angler interviews
D = total number of days available for sampling
m = total number of anglers interviewed.

[b] CPUE = estimated catch per unit effort
SE(CPUE) = standard error of CPUE
HPUE = estimated harvest per unit effort
SE(HPUE) = standard error of HPUE.

Table 21. Demographic profile of anglers interviewed at the lower Chena River, Tanana River drainage, Alaska, 1989.

Angler Characteristic	n[a]	%	SE (%)	Angler Characteristic	n[a]	%	SE (%)
Total Number of Interviews[b]	182	--	--	Local[c]	155	89	2
				Non-local	19	11	2
Male	158	87	2	Tourist	13	7	2
Female	23	13	2	Other	169	93	2
Adult	158	89	2	Gear Type:			
Youth	19	11	2	Spinners	136	94	2
				Bait	6	4	2
Resident	98	59	4	Flies	3	2	1
Non-Resident	16	10	2				
Military	53	31	4				

[a] Number of anglers in the categories will not always equal the total number of interviews because angler demographics were not marked down for all the anglers interviewed.

[b] Includes both complete- and incomplete-trip angler interviews combined.

[c] Local and non-local includes Alaska residents only. Local category are anglers from the Fairbanks-North Pole area.

Table 22. Opinions of anglers interviewed at the lower Chena River, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%[a]	SE (%)
1. How would you rate the quality of fishing for chinook salmon in the lower Chena River this year?	Excellent (1)	61	50	5
	Good (2)	22	18	4
	Fair (3)	34	28	4
	Poor (4)	4	4	2
	Total	121	100	
	Mean Rating =	1.86		
	Median Rating =	1.00		
2. What is the bag limit for chinook salmon in the lower Chena River?	One	132	99	1
	Three	0	0	0
	Other	1	1	0
	Total	133	100	
3. Is public boat access adequate for the lower Chena River?	Yes	123	92	2
	No	7	5	2
	No-Opinion	4	3	1
	Total	134	100	
4. What is your opinion of using reduced seasons and emergency closures to manage chinook salmon in the lower Chena River?	Approve	120	90	3
	Disapprove	8	6	2
	No-Opinion	5	4	2
	Total	133	100	
5. What is your opinion of stocking chinook salmon in the lower Chena River?	Approve	132	98	1
	Disapprove	1	1	0
	No-Opinion	1	1	0
	Total	134	100	

[a] Percentages are calculated for anglers with opinions only and do not take into account anglers in the no-opinion category.

estimate of 685 chinook salmon in 1989 represented almost a three fold increase in harvest over Mills' (1987, 1988) estimates of 212 and 195 chinook salmon harvested in 1986 and 1987, respectively, and nearly 13 times the harvest Mills (1989) estimated in 1988 (55 chinook salmon).

CHAPTER 4 - DELTA CLEARWATER RIVER ARCTIC GRAYLING FISHERY

Introduction

The Delta Clearwater River provides a popular Arctic grayling sport fishery. The river is located approximately 13 km northeast of Delta Junction (Figure 12). The main channel of the river is approximately 32 km long. The river drains an area of about 1,000 km^2. Public access to the river is available at the State of Alaska Clearwater Campground at river kilometer 13 and at the U.S. Army facility on Clear Lake (Figure 12).

Fishing begins on the Delta Clearwater River in mid to late May when the larger Arctic grayling begin to migrate to their summer feeding areas in the upper part of the river. From 1977 to 1987, an average of 6,558 angler-days were expended annually to harvest an average of 5,698 Arctic grayling (Mills 1979-1988). In 1986, angler effort peaked at 10,137 angler days. However, in 1986, harvest dropped to its lowest level (2,343 fish) since 1977 (Mills 1979-1988). Because of concern for the fishery and the decline in harvest, emergency regulations were set forth on the Delta Clearwater River to protect the Arctic grayling stock(s) in 1987. These emergency regulations became permanent regulations in 1988. The regulations implemented were:

1) a 12 inch minimum length limit for Arctic grayling;

2) a no-bait restriction (only artificial flies and lures may be used); and,

3) catch and release Arctic grayling fishing from 1 April to the first Saturday of June each year.

To examine the effects of these new regulations, an on-site creel survey was initiated on the Delta Clearwater River in 1986. Point estimates for angler-effort have varied, however considering the error measured, angler-effort has remained similar between 1986 (5,481 hour with SE = 645), 1987 (4,476 hours with SE = 533), and 1988 (4,433 hours with SE = 362; Clark and Ridder 1987; Baker 1988, 1989). However, estimated harvest of Arctic grayling was greater in 1988 (3,330 fish with SE = 360) compared to 1987 (1,838 fish with SE = 450) and 1986 (1,701 fish with SE = 634).

A creel survey was continued on the Delta Clearwater River during 1989. The program was changed to be more cost-effective in 1989 by deleting the angler count, which had required lengthy time intervals for boating up and down the river. Exit interviews at the boat ramp were emphasized in 1989. The long term goals of this creel survey were to: (1) develop a historical database to allow the monitoring of both the recreational fishery and the exploited fish populations; (2) develop management regulations that reflect the desires of

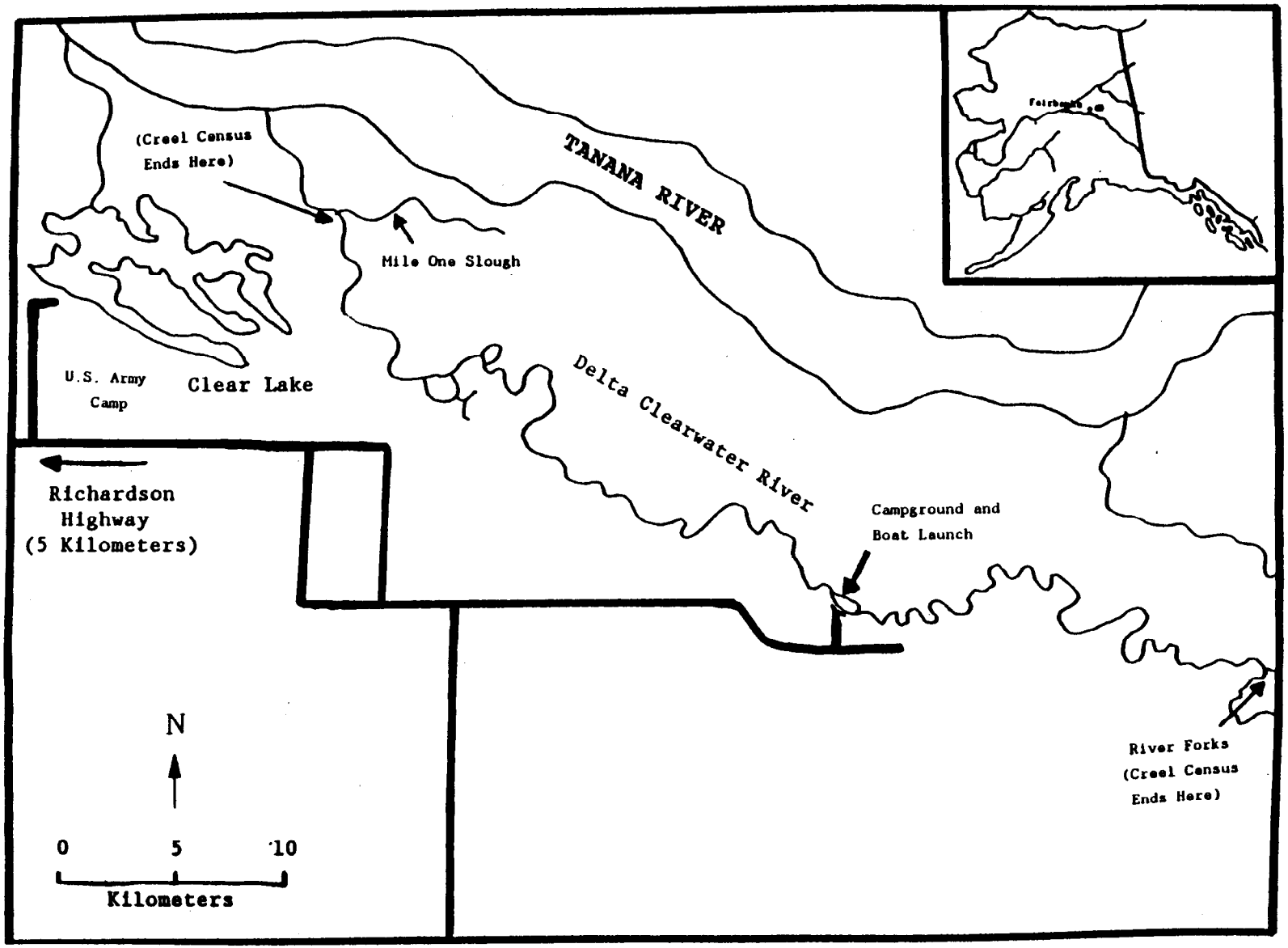

Figure 12. Map of the Delta Clearwater River, Tanana River drainage, Alaska.

the angling public while ensuring the sustained health of the fish populations; and (3) evaluate the effect of management regulations and enhancement programs on the fishery. The specific objectives of the creel survey were to:

1) estimate catch per unit of effort (CPUE) and harvest per unit of effort (HPUE), for Arctic grayling at the Delta Clearwater River;

2) estimate percent age composition for Arctic grayling in the harvest sample from the Delta Clearwater River;

3) estimate the percent composition of angler demographics for the Delta Clearwater River that include: a) male/female, b) adult/youth, c) resident/non resident/military, d) local/non-local, e) tourist/ other, and f) terminal fishing gear (spinner/bait/flies/jigs/trollin g/spear/bow and arrow);

4) estimate the percent response (opinions) to questions asked anglers at the Delta Clearwater River; and,

5) estimate the rating by anglers of the quality of fishing.

Methods

Approximately 50% of the angling effort is from shore-based anglers who fish within 1.6 km of access areas at the State of Alaska Clearwater campground and the U.S. Army camp on Clear Lake. The remainder of the effort is from anglers using river boats and cabin owners along the entire 32 km of the river. Ridder (1984) found that approximately 98% of the fishing effort occurs on the 32 km section of the mainstem Delta Clearwater River that is creel surveyed.

This creel survey was a multi-stage survey with two strata. The total number of desired sample days was 90. These were apportioned by month, so that approximately 30 samples were collected per month over a three month season. Two stages of sampling occurred within each stratum: the sampled day was the first stage, and the angler interviewed was the second stage. Days were stratified into weekdays and weekends, including holidays. Within a day there was a two hour sampling period. These periods occurred within a possible 12 hour day. On weekdays, and weekends periods randomly chosen within the following time blocks were: 0900 to 1300 hours; 1300 to 1700 hours; or 1700 to 2100 hours. Sampling effort was equally distributed among strata. Days, and periods within days were randomly chosen, allowing for optimization depending upon weather. If weather was inclement, and the number of anglers on the Delta Clearwater River judged to be zero, then the period which would have been sampled was randomly allocated to another portion of that day or another day.

Several assumptions were required for analysis of this creel survey. As is usual with a CPUE survey, it was assumed that either anglers were interviewed in proportion to their abundance, or that CPUE did not vary from sample period to sample period. For the Delta Clearwater survey, it was also assumed that

no anglers fished on sample periods which were re-scheduled due to inclement weather, or that CPUE was not different during inclement weather conditions from that during good weather conditions. Very few sample periods were re-scheduled.

CPUE and HPUE of anglers participating in the 1989 Delta Clearwater Arctic grayling fishery were estimated by the procedures outlined in Chapter 2, equations 57-72, with some exceptions.

Since anglers were not counted, the sample weights (W_{hi}) used in equation 57 were calculated approximately by:

$$W_{ni} = m_{hi} / \bar{m}_h \; ; \tag{73}$$

where:

$$\bar{m}_h = \frac{\sum_{i=1}^{d_n} m_{ni}}{d_n} \; . \tag{74}$$

HPUE estimates were obtained similarly by replacing the catch statistics (C's) with the appropriate harvest statistics.

Estimates of mean CPUE or HPUE across all strata were not obtained because there was no estimate of the angler effort (or number of anglers) in each stratum. As such "stratum weights" can not be obtained. If "guessed" weights were to be used then the resulting mean would most likely be biased (Sukhatme et al. 1984).

Results and Discussion

The Delta Clearwater Arctic grayling creel survey began on 5 June and continued through 31 August 1989. During this time 85 days were sampled, of which 25, 31, and 29 days were in June, July and August, respectively (Table 23). Forty eight percent of the sampling effort was on weekdays, and 52% was on weekends. The majority (36%) of interviews were obtained during weekends, 1300-1700 hours (Table 23).

During the creel survey, 365 anglers were interviewed. Mean CPUE and HPUE in time block A (early morning, weekdays) was low (0 to 0.5) in contrast to the other time blocks (Table 23). The greatest mean CPUE (5.51, SE = 2.17) and HPUE (1.59, SE = 0.82) were in June, although variances were high around mean estimates.

Survey strata (weekdays, weekends) were chosen because it was assumed that angler effort varied among strata: more effort occurred at certain times of the day and on weekends. The purpose of stratification is to minimize bias and improve precision (Schaeffer et al. 1986). Thus, CPUE and HPUE within

Table 23. Angler CPUE and HPUE estimates for the Delta Clearwater River Arctic grayling creel survey during the 5 June - 31 August 1989 period.

	Strata	Sampling Information[a]			Parameter Estimates[b]			
		d	D	m	CPUE	SE(CPUE)	HPUE	SE(HPUE)
June	Weekdays/0900-1300	2	20	2	0.00	0.00	0.00	0.00
	Weekdays/1300-1700	5	20	8	1.53	0.34	0.65	0.19
	Weekdays/1700-2100	3	20	10	0.58	0.26	0.19	0.05
	Weekends/0900-1300	5	6	11	5.51	2.17	1.59	0.82
	Weekends/1300-1700	6	6	42	1.13	0.20	0.61	0.12
	Weekends/1700-2100	4	6	20	0.89	0.35	0.47	0.17
July	Weekdays/0900-1300	6	21	6	0.00	0.00	0.00	0.00
	Weekdays/1300-1700	5	21	23	1.91	0.79	0.44	0.33
	Weekdays/1700-2100	5	21	36	0.84	0.27	0.40	0.15
	Weekends/0900-1300	5	10	23	1.21	0.33	0.69	0.18
	Weekends/1300-1700	5	10	51	1.03	0.29	0.53	0.18
	Weekends/1700-2100	5	10	36	1.58	0.30	0.69	0.14
August	Weekdays/0900-1300	5	23	8	0.56	0.43	0.00	0.00
	Weekdays/1300-1700	5	23	14	1.77	0.65	0.96	0.38
	Weekdays/1700-2100	5	23	9	0.88	0.62	0.00	0.00
	Weekends/0900-1300	5	8	6	1.11	1.29	0.00	0.00
	Weekends/1300-1700	5	8	37	1.43	0.61	0.38	0.18
	Weekends/1700-2100	4	8	23	1.22	0.31	0.17	0.07

[a] d = number of days sampled for angler interviews
D = total number of days available for sampling
m = total number of anglers interviewed.

[b] CPUE = estimated catch per unit effort
SE(CPUE) = standard error of CPUE
HPUE = estimated harvest per unit effort
SE(HPUE) = standard error of HPUE.

strata are fairly precise. In the present analysis, estimates of mean CPUE and HPUE across strata (for an entire week or an entire month) were not estimated because stratum weights (angler counts) were not obtained. Stratum weights could have been guessed, based on present knowledge of the fishery, sampling strategy, and past angler counts relative to anglers interviewed. However, guessing would have introduced bias into the estimate.

The distribution of angler harvest (obtained from completed-trip interviews) shows that the majority of anglers kept no Arctic grayling (Figure 13). The frequency of harvest diminishes with increasing bags, however, more anglers harvest the bag limit (five per day) than those harvesting two to four fish per day. The most Arctic grayling harvested by any angler interviewed was six.

Biological data were collected from 464 Arctic grayling during the creel survey. Harvested Arctic grayling ranged in age from 3 to 12 years (Table 24). Age 6 Arctic grayling made up 29% of the harvest sample. The mean fork length of all Arctic grayling harvested was 328 mm, which was approximately the same length as an age 6 fish. Ninety-seven percent of the Arctic grayling in the harvest sample were in the quality and preferred length categories with no fish in the memorable or trophy length categories. The average age of Arctic grayling in the harvest sample has increased from 4 to 5 years in 1977 to 1985, to 6 years in 1986 through 1989. The average length of Arctic grayling has correspondingly increased in the harvest sample since 1977 (Table 25). Regulatory action taken in 1987 to limit the minimum length of Arctic grayling in the harvest (12 inches or 304.8 mm) is primarily responsible for the trend in harvest of older and larger fish.

The majority of the anglers interviewed were male (73%), adult (91%), and residents of the State of Alaska (81%; Table 26). Of the anglers interviewed that were residents, 79% were from outside the Delta Junction area. Non-residents and military personnel, respectively, made up 16% and 3% of the anglers interviewed. Fifteen percent of the anglers interviewed were tourists. Most of anglers interviewed used spinners (55%) or flies (33%) as their terminal gear type with the rest using jigs (12%).

Anglers interviewed at the Delta Clearwater River gave the fishery a median rating of 2 or good (Table 27). Of these, 18% rated the fishery excellent, 34% rated it good, 37% rated it fair, and 11% rated it poor. The majority of the anglers interviewed approved of the current management regulations, with 97% approving of a 12 inch minimum length limit for Arctic grayling, 98% approving of a no-bait restriction at the Delta Clearwater River, and 94% approving of catch-and-release fishing only until the first Saturday in June.

CHAPTER 5 - PILEDRIVER SLOUGH RAINBOW TROUT AND ARCTIC GRAYLING FISHERY

Introduction

Piledriver Slough supports a popular fishery for rainbow trout and Arctic grayling. Piledriver Slough is a slough of the Tanana River originating about 48 km east of Fairbanks near Eielsen Air Force Base (Figure 14). Dike

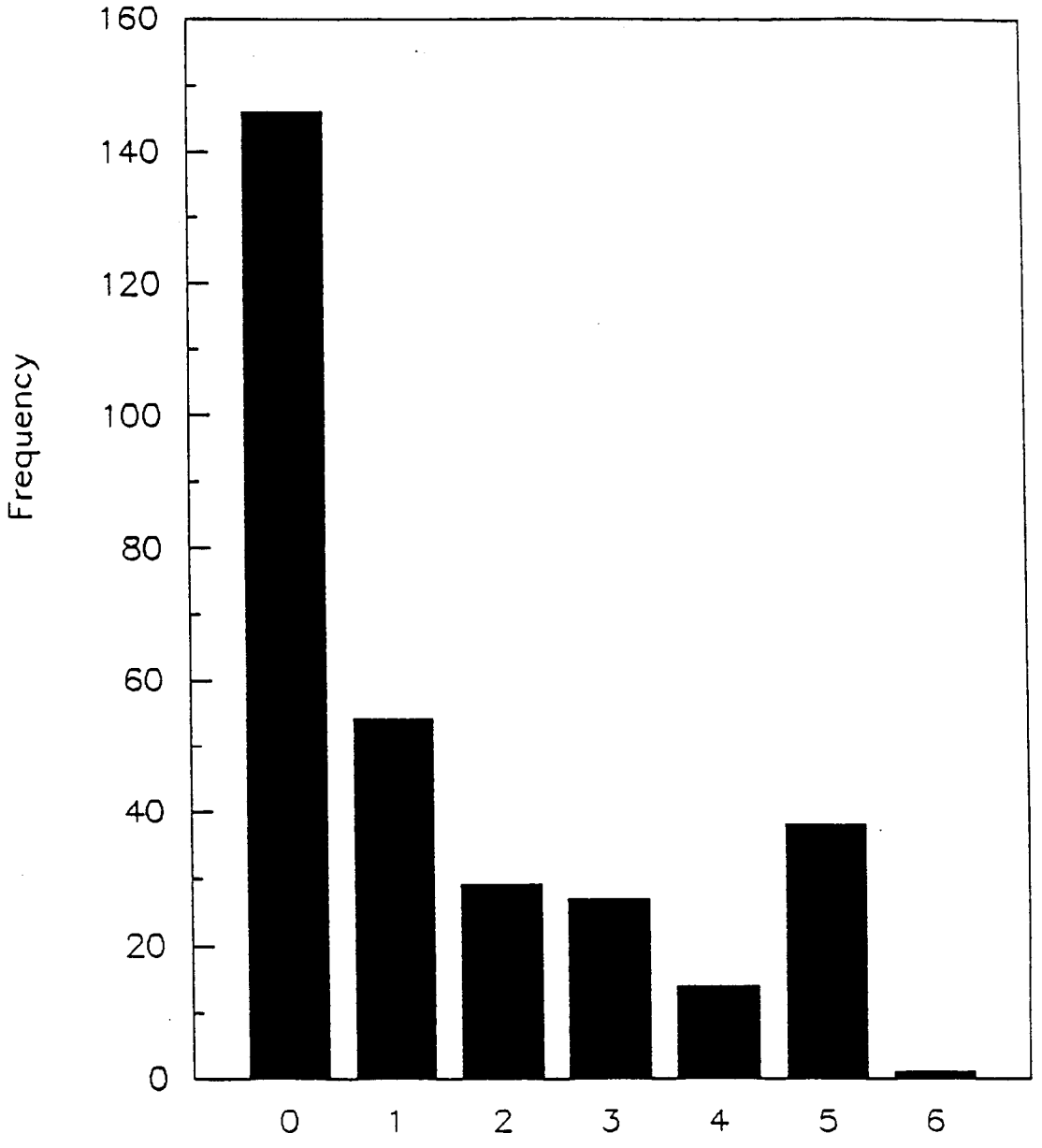

Figure 13. Distribution of Arctic grayling harvest among anglers interviewed at the Delta Clearwater River, Tanana River drainage, Alaska, 1989.

Table 24. Estimates of the contributions of each age class, mean fork length (mm) at age, and Relative Stock Density (RSD) of Arctic grayling in the harvest sample from the Delta Clearwater River, Tanana River drainage, Alaska, 1989.

	Age Composition			Fork Length[a]		Relative Stock Density (RSD)				
Age	n	%	SE (%)	Mean	SE	Category	Range[b]	n	%	SE(%)
3	12	3	1	265	4	Stock	150-269	14	3	1
4	88	21	2	301	2	Quality	270-339	298	64	2
5	71	17	1	307	2	Preferred	340-449	152	33	2
6	123	29	2	325	2	Memorable	450-559	0	0	--
7	67	16	2	350	3	Trophy	750-up	0	0	--
8	25	6	2	379	3					
9	15	4	1	386	4	Total		464	100	
10	13	3	1	393	4					
11	3	<1	<1	400	9					
12	4	1	<1	421	8					
Total	421	100		328	2					

[a] Fork length is in millimeters (mm).
[b] Range is the fork length range of the RSD category in mm.

Table 25. Number of Arctic grayling by age class in the harvest sample from the Delta Clearwater River, and average length (mm) by year, 1977 to 1989.[a]

Age Class	1977[c] n	1978[d] n	1979[e] n	1980[e] n	1981[e] n	1982[e] n	1983[e] n	1984[e] n	1985[e] n	1986[f] n	1987[b],[g] n	1988[b],[h] n	1989[b] n	Totals n	Totals %
1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0.0
2	5	2	4	7	2	1	0	0	11	1	0	3	0	36	1.5
3	16	8	38	19	31	10	8	1	2	5	3	14	12	167	7.0
4	33	27	44	61	43	28	22	15	26	11	28	33	88	459	19.2
5	46	19	101	35	48	24	59	23	49	23	53	166	71	717	30.0
6	26	18	24	18	18	20	17	23	29	29	43	72	123	460	19.3
7	12	29	13	4	9	6	16	6	32	13	31	64	67	302	12.8
8	1	8	1	3	1	1	2	6	10	9	26	41	25	134	5.6
9	0	0	0	0	1	2	0	1	3	3	14	19	15	58	2.4
10	0	0	0	0	0	0	1	1	0	2	7	10	13	34	1.4
11	0	0	0	0	0	0	0	0	0	2	4	6	3	15	0.6
12	0	0	0	0	0	0	0	0	0		0	0	4	4	0.2
13	0	0	0	0	0	0	0	0	0		0	0	0	0	0.0
n=	139	111	225	147	153	92	125	76	163	98	209	428	421	2,387	100.0
Avg.Age=	4.9		4.6	4.4	4.6	4.9	5.2	5.6	5.4	5.9	6.3	6.0	5.9	5.4	
Avg.Len=	284		273	277	281	290	293	307	299	310	338	326	328		

[a] Samples collected from about 15 May to 5 September for 1977-1986; 4 June to 5 September 1987-1988; and 1 June to 28 August 1989.
[b] Twelve inch total length and spring closure.
[c] Peckham (1978)
[d] Peckham and Ridder (1979)
[e] Holmes et al. (1986)
[f] Clark and Ridder (1987)
[g] Baker (1988)
[h] Baker (1989)

Table 26. Demographic profile of anglers interviewed at the Delta Clearwater River, Tanana River drainage, Alaska, 1989.

Angler Characteristic	n[a]	%	SE (%)	Angler Characteristic	n[a]	%	SE(%)
Total Number of Interviews[b]	365	--	--	Local[c]	77	21	3
				Non-local	286	79	3
Shore Anglers	100	28	2	Guided	44	11	2
Boat Anglers	251	72	2	Unguided	303	89	2
Male	265	73	3	Tourist	55	15	2
Female	100	27	3	Other	310	85	2
Adult	333	91	2	Gear Type:			
Youth	30	9	2	Spinners	198	55	3
				Jigs	42	12	2
Resident	293	81	3	Flies	122	33	3
Non-Resident	58	16	2				
Military	12	3	1				

[a] Number of anglers in the categories will not always equal the total number of interviews because angler demographics were not marked down for all the anglers interviewed.

[b] Includes both complete- and incomplete-trip angler interviews combined.

[c] Local and non-local category includes Alaska residents only. Local category are anglers from the Delta Junction area.

Table 27. Opinions of anglers interviewed at the Delta Clearwater River, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%[a]	SE(%)
1. How would you rate the quality of Arctic grayling fishing at the Delta Clearwater River this year?	Excellent (1)	37	18	3
	Good (2)	95	34	3
	Fair (3)	49	37	3
	Poor (4)	17	11	2
	Total	211	100	
	Mean Rating = 2.41			
	Median Rating = 2.00			
2. What is your opinion of a 12 inch minimum length limit for Arctic grayling in the Delta Clearwater River?	Approve	204	97	1
	Disapprove	6	3	1
	No Opinion	0	--	--
	Total	210	100	
3. What is your opinion of restricting the use of bait in the Delta Clearwater River (Only artificial flies and lures may be used?)	Approve	203	98	1
	Disapprove	4	2	1
	No Opinion	3	--	--
	Total	210	100	
4. What is your opinion of catch and release fishing only for Arctic grayling in the Delta Clearwater River until the first Saturday in June?	Approve	197	94	2
	Disapprove	12	6	2
	No Opinion	1	--	--
	Total	210	100	

[a] Percentages are calculated for anglers with opinions only and do not take into account anglers in the no-opinion category.

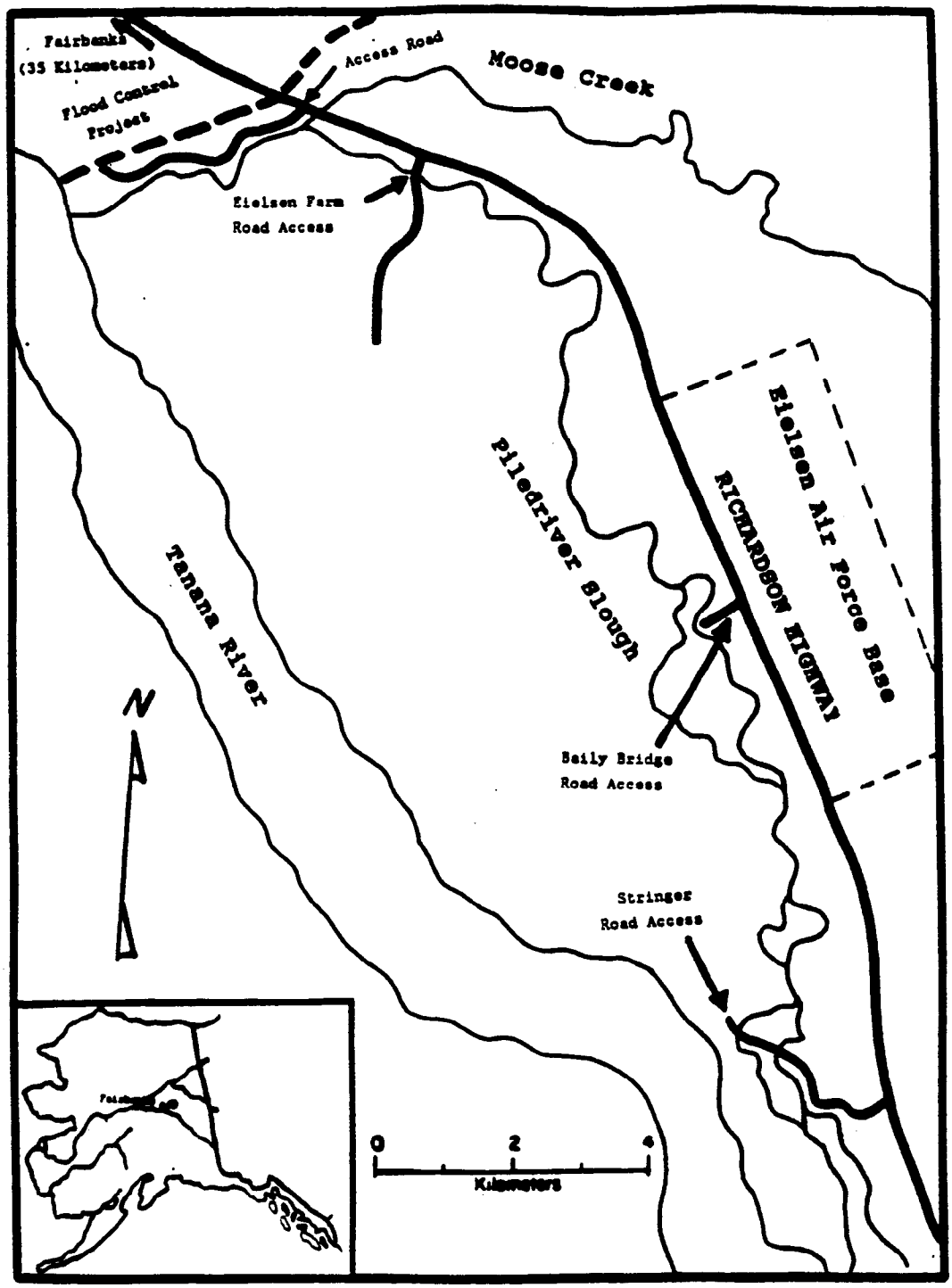

Figure 14. Map of Piledriver Slough, Tanana River drainage, Alaska.

construction from the Moose Creek Flood Control Project blocked the mouth of the Slough in the late 1970's. With the silty waters of the Tanana River blocked, clear spring water began to flow. Because of this, Arctic grayling began using Piledriver Slough and an early season fishery developed.

During the summer of 1987, the Division of Sport Fish, Alaska Department of Fish and Game, stocked rainbow trout in Piledriver Slough. This was the first stocking of rainbow trout into an open system (not landlocked) in the interior of Alaska. Catchable, sub-catchable, and fingerling size rainbow trout were stocked in 1987, 1988 and 1989.

Because of close proximity of Piledriver Slough to the Fairbanks-North Pole area and the stocking of rainbow trout, there was concern for the potential overharvest of spawning size Arctic grayling in Piledriver Slough. For these reasons, management regulations were initiated for Piledriver Slough that included:

1) a 12 inch minimum length limit for Arctic grayling; and,

2) a no-bait restriction (only artificial flies and lures can be used).

In 1986, the year prior to the stocking of rainbow trout and the new regulations were put into effect, no estimate was available for the amount of angler-effort and harvest of Arctic grayling at Piledriver Slough. However, Mills (1986) estimated that 3,500 angler-days were expended on Piledriver Slough in 1985 to harvest 2,000 Arctic grayling. Angler-effort has dramatically increased from 1985 to 1987. Anglers, in 1987, spent an estimated 13,257 angler-days fishing to harvest 4,907 Arctic grayling and 4,346 rainbow trout (Mills 1988). In 1988, anglers spent 24,375 anger-days at Piledriver Slough, and harvested an estimated 12,296 rainbow trout and 8,095 Arctic grayling (Mills 1989).

An on-site creel survey has been conducted at Piledriver Slough since 1985. The mean fork length of harvested Arctic grayling was 250 mm in 1985. Only 4% of the Arctic grayling were of spawning size (> 270 mm; Holmes et al. 1986). In 1986, the mean fork length of Arctic grayling was 243 mm (Clark and Ridder 1987). However, 15% of the Arctic grayling were of spawning size (> 270 mm). In 1987, the mean fork length of Arctic grayling was 248 mm and the number of spawning size fish increased to approximately 30% (Baker 1988). In 1988, only six Arctic grayling were sampled in the creel survey. Of those examined, 50% were of spawning size (Baker 1989).

The long term goals of the Piledriver Slough creel survey are to develop a database of CPUE, HPUE, and biological data for Arctic grayling and rainbow trout to assess the effectiveness of management regulations and determine optimal stocking policies for rainbow trout in streams. The specific objectives of the Piledriver Slough creel survey in 1989 were to:

1) estimate CPUE and HPUE for Arctic grayling and rainbow trout at Piledriver Slough;

2) estimate percent age composition, and mean fork length-at-age for each age class of Arctic grayling; and RSD categories for rainbow trout in the harvest sample from Piledriver Slough;

3) estimate the percent composition of angler demographics for Piledriver Slough that include: a) male/female, b) adult/youth, c) resident/non-resident/military, d) local/non-local, e) tourist/other, and f) terminal fishing gear (spinner/bait/flies/jigs/trolling/spear/bow and arrow);

4) estimate the percent response (opinions) to questions asked anglers at Piledriver Slough; and,

5) estimate the rating of the fishery.

This report will also address an objective outlined in the federal contract, F-10-5, Job T-8-1, which is to estimate the relative contribution of rainbow trout caught in Piledriver Slough that were stocked as fingerlings, small sub-catchables, and large sub-catchables.

Methods

Access to Piledriver Slough is provided at Moose Creek and Stringer Roads, and Eielson Farm and Bailey Bridge turnoffs. All fishing is from shore. Angler-effort was concentrated in the evenings during the weekdays and on weekends. The fishing day was defined to occur from 0800 to 2200 hours. Three sampling strata were used in this fishery: (1) weekdays 0800 to 1600 hours; (2) weekdays 1600 to 2200 hours; and (3) weekends and holidays 0800 to 2200 hours. Sampling effort was optimally allocated based upon the number of anglers interviewed in each stratum in 1987 and 1988. Sampling effort was allocated 12%, 42%, and 46% to strata 1, 2, and 3, respectively. Sampling effort was to be concentrated (75%) at the Eielson Farm turnoff and Moose Creek Road with the remaining 25% divided between the other access points.

About thirty samples per month were collected at randomly selected times distributed among strata as described above. Sample periods were two hours. On occasion, more than one period was sampled within a day, so that within day variance was estimated. While angler counts were not a specific objective of this fishery, they were conducted concurrent with angler interviews at no additional cost. The majority of interviews were from anglers who had not yet completed their fishing trip.

CPUE and HPUE of anglers participating in the 1989 Piledriver Slough fishery were estimated by the procedures outlined in Chapter 2, equations 57-72.

Results and Discussion

The Piledriver Slough creel survey began on 4 May and was conducted through 28 August 1989.

During this time, 75 days were sampled, of which 83% occurred at the Eielson Farm turnoff and Moose Creek Road (Table 28). Forty-five percent of the sampling effort at the Eielson Farm turnoff and Moose Creek Road occurred on weekends.

A total of 452 interviews were obtained which could be used for analysis of angler CPUE and HPUE (Table 28). The greatest proportion (37%) of interviews was obtained during May. Of 413 interviews conducted at the Eielson Farm turnoff and Moose Creek Road, 222 (54%) occurred on weekends, even though weekends comprised only 45% of the sampling effort.

Total fishing trips were estimated at 9,570 for the Piledriver Slough fishery (Tables 28 and 29). Most (8,519) of the fishing trips at Piledriver Slough occurred at the Moose-Eielson areas.

Mean CPUE for the Arctic grayling fishery at Moose-Eielson for the season was 0.79 (SE = 0.16), with the highest CPUE occurring within the May strata (2.46, SE = 0.31; Table 28). Mean CPUE of other sites for the season was 2.18 (SE = 0.71). The highest CPUE also occurred within the May strata (3.60, SE = 1.49). The estimated CPUE of all sites combined for the entire season was 0.94 (SE = 0.16). Mean HPUE in the Moose-Eielson strata for the season was 0.05 (SE = 0.02). The highest HPUE was 0.37 (SE = 0.37) and was within the May strata. The mean HPUE of other sites for the season was 0.05 (SE = 0.05), with the highest HPUE within the July strata (0.21, SE = 0.20). Mean HPUE of all sites combined was 0.05 (SE = 0.02).

Mean CPUE for the rainbow trout fishery at Moose-Eielson for the season was 0.72 (SE = 0.34), with the highest CPUE occurring within the August strata (2.72, SE = 2.66; Table 29). Mean CPUE of other sites for the season was 0.35 (SE = 0.22). The highest CPUE also occurred within the August strata (5.21, SE = 5.08). The estimated CPUE of all sites combined for the entire season was 0.68 (SE = 0.30). Mean HPUE in the Moose-Eielson strata for the season was 0.16 (SE = 0.06). The highest HPUE was 0.41 (SE = 0.36) and was within the June strata. The mean HPUE of other sites for the season was 0.05 (SE = 0.04), with the highest HPUE within the August strata (0.52, SE = 0.54). Mean HPUE of all sites combined was 0.15 (SE = 0.05).

The distribution of the harvest among anglers interviewed (including incomplete and completed interviews) shows the majority of anglers with zero harvest (Figure 15). Incomplete trip interviews comprised a substantial portion of data collected and point out a failing in the design of this creel survey because of low numbers of completed-trip interviews obtained. The harvest distribution (Figure 15) thus under-emphasizes the magnitude of the harvest, as estimated with the statewide harvest survey.

Biological data were collected from 29 Arctic grayling and 73 rainbow trout in the harvest sample at Piledriver Slough. Three percent of the Arctic grayling in the harvest sample were under stock length, 45% were stock length, and the remaining 52% were quality length (Table 30). Twenty-nine percent of the rainbow trout in the harvest sample were under stock length and 37%, 30% and 4% were of stock, quality and preferred lengths, respectively (Table 30). No

Table 28. Angler CPUE and HPUE estimates for the Piledriver Slough Arctic grayling fishery during the 1 May - 31 August 1989 period.

Strata			Sampling Information[a] d	D	m	Parameter Estimates[b] CPUE	SE(CPUE)	HPUE	SE(HPUE)	$\hat{A}$
Moose-Eielson	May	Weekday/0800-1600	2	22	16	2.46	0.31	0.37	0.37	---[c]
		Weekday/1600-2200	8	22	58	1.96	0.51	0.09	0.05	973
		Weekend/0800-2200	7	9	81	1.86	0.41	0.02	0.01	407
	June	Weekday/0800-1600	3	22	10	0.74	0.77	0.00	0.00	1,097
		Weekday/1600-2200	5	22	31	0.77	0.68	0.01	0.01	614
		Weekend/0800-2200	7	8	40	0.29	0.16	0.19	0.13	1,059
	July	Weekday/0800-1600	3	20	17	0.00	0.00	0.00	0.00	813
		Weekday/1600-2200	7	20	31	0.19	0.14	0.17	0.13	303
		Weekend/0800-2200	8	11	53	0.10	0.05	0.00	0.00	777
	August	Weekday/0800-1600	2	23	8	0.07	0.07	0.00	0.00	1,037
		Weekday/1600-2200	4	23	20	1.04	0.34	0.01	0.01	517
		Weekend/0800-2200	6	8	48	1.88	0.82	0.10	0.09	922
	All Season	All time periods	---	---	413	0.79[d]	0.16[d]	0.05[d]	0.02[d]	8,517[e]
All other sites	May	All time periods	4	31	14	3.60	1.49	0.00	0.00	416
	June	All time periods	3	30	10	1.29	0.85	0.00	0.00	357
	July	All time periods	4	31	10	1.20	0.99	0.21	0.20	278
	August	All time periods	2	31	5	1.04	1.07	0.00	0.00	---[c]
	All Season	All time periods	---	---	39	2.18[d]	0.71[d]	0.05[d]	0.05[d]	1,051[e]
All sites combined	May	All time periods	---	---	169	2.32[d]	0.45[d]	0.06[d]	0.03[d]	1,796[e]
	June	All time periods	---	---	91	0.66	0.32	0.06	0.04	3,137
	July	All time periods	---	---	111	0.22	0.13	0.05	0.03	2,171
	August	All time periods	---	---	81	0.95[d]	0.31[d]	0.04[d]	0.03[d]	2,467[e]
All sites combined	All Season	All time periods	---	---	452	0.94[d]	0.16[d]	0.05[d]	0.02[d]	9,570[e]

[a] d = number of days sampled for angler interviews
D = total number of days available for sampling
m = total number of anglers interviewed.

[b] CPUE = estimated catch per unit effort
SE(CPUE) = standard error of CPUE
HPUE = estimated harvest per unit effort
SE(HPUE) = standard error of HPUE.
$\hat{}$

[c] Fishing trips could not be estimated because no completed trip interviews were conducted in this stratum.

[d] Biased due to inability to properly weight strata in which fishing trips could not be estimated.

[e] Minimal estimate due to inability to estimate some of the associated stratum estimates.

Table 29. Angler CPUE and HPUE estimates for the Piledriver Slough rainbow trout fishery during the 1 May - 31 August 1989 period.

Strata			Sampling[a] Information d	D	m	CPUE	[b] Parameter Estimates SE(CPUE)	HPUE	SE(HPUE)	$\hat{A}$
Moose-Eielson	May	Weekday/0800-1600	2	22	16	2.46	1.08	0.00	0.00	---[c]
		Weekday/1600-2200	8	22	58	0.39	0.15	0.12	0.07	973
		Weekend/0800-2200	7	9	81	0.26	0.11	0.03	0.02	407
	June	Weekday/0800-1600	3	22	10	0.07	0.08	0.07	0.08	1,097
		Weekday/1600-2200	5	22	31	0.96	0.73	0.41	0.36	614
		Weekend/0800-2200	7	8	40	1.05	0.48	0.27	0.12	1,059
	July	Weekday/0800-1600	3	20	17	0.00	0.00	0.00	0.00	813
		Weekday/1600-2200	7	20	31	0.30	0.17	0.23	0.17	303
		Weekend/0800-2200	8	11	53	0.28	0.11	0.13	0.06	777
	August	Weekday/0800-1600	2	23	8	2.72	2.66	0.37	0.37	1,037
		Weekday/1600-2200	4	23	20	0.59	0.56	0.05	0.05	517
		Weekend/0800-2200	6	8	48	0.42	0.20	0.02	0.02	922
	All Season	All time periods	---	---	413	0.72[d]	0.34[d]	0.16[d]	0.06[d]	8,517[e]
All other sites	May	All time periods	4	31	14	0.61	0.54	0.00	0.00	416
	June	All time periods	3	30	11	0.10	0.11	0.11	0.10	357
	July	All time periods	4	31	10	0.26	0.10	0.07	0.07	278
	August	All time periods	2	31	5	5.21	5.08	0.52	0.54	---[c]
	All Season	All time periods	---	---	39	0.35[d]	0.22[d]	0.05[d]	0.04[d]	1,051[e]
All sites combined	May	All time periods	---	---	169	0.41[d]	0.15[d]	0.07[d]	0.04[d]	1,796[e]
	June	All time periods	---	---	91	0.58	0.22	0.21	0.09	3,137
	July	All time periods	---	---	111	0.18	0.05	0.09	0.03	2,171
	August	All time periods	---	---	81	1.42[d]	1.12[d]	0.17[d]	0.15[d]	2,467[e]
All sites combined	All Season	All time periods	---	---	452	0.68[d]	0.30[d]	0.15[d]	0.05[d]	9,570[e]

[a] d = number of days sampled for angler interviews
D = total number of days available for sampling
m = total number of anglers interviewed.

[b] CPUE = estimated catch per unit effort
SE(CPUE) = standard error of CPUE
HPUE = estimated harvest per unit effort
SE(HPUE) = standard error of HPUE.
$\hat{A}$ = estimated number of fishing experiences

[c] Fishing trips could not be estimated because no completed trip interviews were conducted in this stratum.

[d] Biased due to inability to properly weight strata in which fishing trips could not be estimated.

[e] Minimal estimate due to inability to estimate some of the associated stratum estimates.

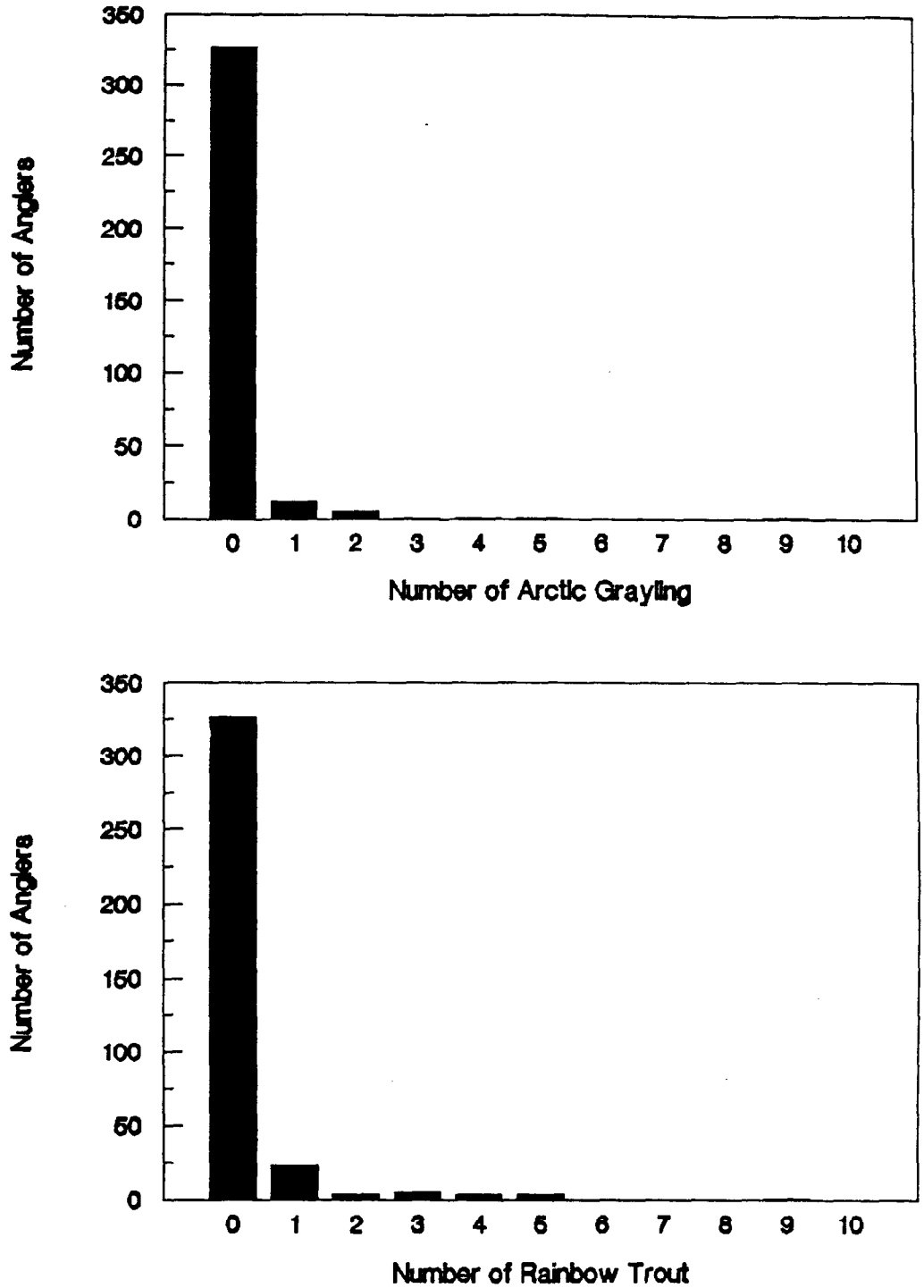

Figure 15. Distribution of Arctic grayling and rainbow trout harvest among anglers interviewed at Piledriver Slough, Tanana River drainage, Alaska, 1989.

Table 30. Relative Stock Density (RSD) of Arctic grayling and rainbow trout in the harvest sample at Piledriver Slough, Tanana River drainage, Alaska, 1989.

Category	Range[a]	n	%	SE (%)
Arctic Grayling				
Stock	150-269	13	45	9.4
Quality	270-339	15	52	9.4
Preferred	340-449	0	0	---
Memorable	450-559	0	0	---
Trophy	560-above	0	0	---
Other	< 150	1	3	3.2
Total		29	100	
Rainbow Trout				
Stock	180-224	27	37	5.7
Quality	225-299	22	30	5.4
Preferred	300-374	3	4	2.3
Memorable	375-449	0	0	---
Trophy	450-above	0	0	---
Other	< 180	21	29	5.4
Total		73	100	

[a] Range is the fork length range of the RSD category in mm.

Arctic grayling in the harvest sample were in the preferred length category and no Arctic grayling or rainbow trout were in the memorable or trophy length categories. The mean fork length of the sampled Arctic grayling was 269 mm (SE = 6) and the mean fork length of the sampled rainbow trout was 200 mm (SE = 5; Table 31). The mean fork length for Arctic grayling of age two was 220 mm (SE = 30), of age three was 259 mm (SE = 12), of age four was 266 mm (SE = 6), and for grayling of ages five, six and seven the mean fork length was 282 mm (SE = 8), 284 mm (SE = 1), and 290 mm (SE = 6), respectively (Table 31). The mean fork lengths found for rainbow trout of ages zero, one and two were 148 mm (SE = 4), 214 mm (SE = 4), and 294 mm (SE = 13), respectively.

In 1989, 34,200 subcatchable (approximately 125 mm to 160 mm) and large subcatchable (approximately 190 mm to 240 mm), and 35,000 fingerling rainbow trout were stocked in Piledriver Slough. The fingerlings stocked in 1989 were not available in the 1989 harvest, so the harvest in 1989 was comprised of subcatchables and large subcatchables stocked in 1989, and subcatchables, large subcatchables, and fingerlings stocked in 1987 and 1988. All age 0, and an unknown portion of age 1 rainbow trout in the harvest sample were fish stocked in 1988. All age 2 fish were from previous years' stockings. Thus, based on the size composition (Table 30) and age composition (Table 31), some portion of the harvest in 1989 was comprised of rainbow trout that had survived and grown from previous years' stockings. The harvest sample cannot be partitioned into a percentage of fish stocked by size class and year because stocked fish were not marked, and there is overlap in the age 1 cohort between fish stocked in 1988 and those stocked in 1989.

The majority of the anglers interviewed at Piledriver Slough were male (88%), adult (82%), and residents of the State of Alaska (51%; Table 32). The fishery was also popular for military personnel (43%). Six percent of the anglers were non-residents. Of the anglers interviewed who were residents, 71% were from the Fairbanks-North Pole area. Only 9% of all the anglers were tourists. The anglers were almost evenly split on their choice of terminal fishing gear with 49% using flies and 46% using spinners. Even though Piledriver Slough was closed to the use of bait, 4% of the anglers interviewed used bait.

Anglers that were interviewed gave the Piledriver Slough fishery a median rating of 2, which is a rating of good (Table 33). When asked opinions about management regulations, the anglers were highly in favor of stocking rainbow trout (94%), approved of a 12 inch minimum length limit for Arctic grayling (82%), and approved of a no-bait restriction at Piledriver Slough (74%).

CHAPTER 6 - SALCHA RIVER CHINOOK SALMON FISHERY

Introduction

The Salcha River is located about 67 km east of Fairbanks on the Richardson Highway (Figure 16). The Salcha River supports a popular chinook and chum salmon recreational fishery that occurs during July. The chinook salmon run in the Salcha River is the largest documented run in the middle Yukon River drainage (Barton 1985). Chum salmon migrate up the Salcha River in late July,

Table 31. Estimates of the contributions of each age class and mean fork length (mm) at age of Arctic grayling and rainbow trout in the harvest sample at Piledriver Slough, Tanana River drainage, Alaska, 1989.

		Age Composition			Fork Length[a]	
Species	Age	n	%	SE (%)	mean	SE
Arctic Grayling	2	3	10	6	220	30
	3	5	17	7	259	12
	4	6	21	8	266	6
	5	11	38	9	282	8
	6	2	7	5	284	1
	7	2	7	5	290	6
Total		29	100		269	6
Rainbow Trout	0	21	34	6	148	4
	1	37	60	6	214	4
	2	4	6	3	294	13
Total		62	100		200	5

[a] Fork length is in millimeters (mm).

Table 32. Demographic profile of anglers interviewed at Piledriver Slough, Tanana River drainage, Alaska, 1989.

Angler Characteristic	n[a]	%	SE	Angler Characteristic	n[a]	%	SE(%)
Total Number of Interviews[b]	532	--	--	Local[c]	358	71	2
				Non-local	147	29	2
Male	469	88	1	Tourist	50	9	1
Female	63	12	1	Other	488	91	1
Adult	432	82	2	Gear Type:			
Youth	96	18	2	Spinners	223	46	2
				Bait	18	4	1
Resident	267	51	2	Jigs	6	1	1
Non-Resident	32	6	1	Flies	235	49	2
Military	222	43	2				

[a] Number of anglers in the categories will not always equal the total number of interviews because angler demographics were not marked down for all the anglers interviewed.

[b] Includes both complete- and incomplete-trip angler interviews combined.

[c] Local and non-local includes Alaska residents only. Local category are anglers from the Fairbanks-North Pole area.

Table 33. Opinions of anglers interviewed at Piledriver Slough, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%[a]	SE(%)
1. How would you rate the quality of fishing at Piledriver Slough this year?	Excellent (1)	26	6	1
	Good (2)	139	31	2
	Fair (3)	88	19	2
	Poor (4)	68	15	2
	No Opinion (5)	132	29	2
	Total	453	100	
	Mean Rating =	1.90		
	Median Rating =	2.00		
2. What is your opinion of stocking rainbow trout in Piledriver Slough?	Approve	441	94	1
	Disapprove	7	1	1
	No Opinion	21	4	1
	Total	469	100	
3. What is your opinion of a 12 inch minimum length limit for Arctic grayling in Piledriver Sloughiver?	Approve	384	82	2
	Disapprove	50	11	1
	No Opinion	32	7	1
	Total	466	100	
4. What is your opinion of restricting the use of bait in Piledriver Slough (only artificial flies and lures may be used)?	Approve	321	74	2
	Disapprove	83	19	2
	No Opinion	31	7	1
	Total	435	100	

[a] Percentages are calculated for anglers with opinions only and do not take into account anglers in the no-opinion category.

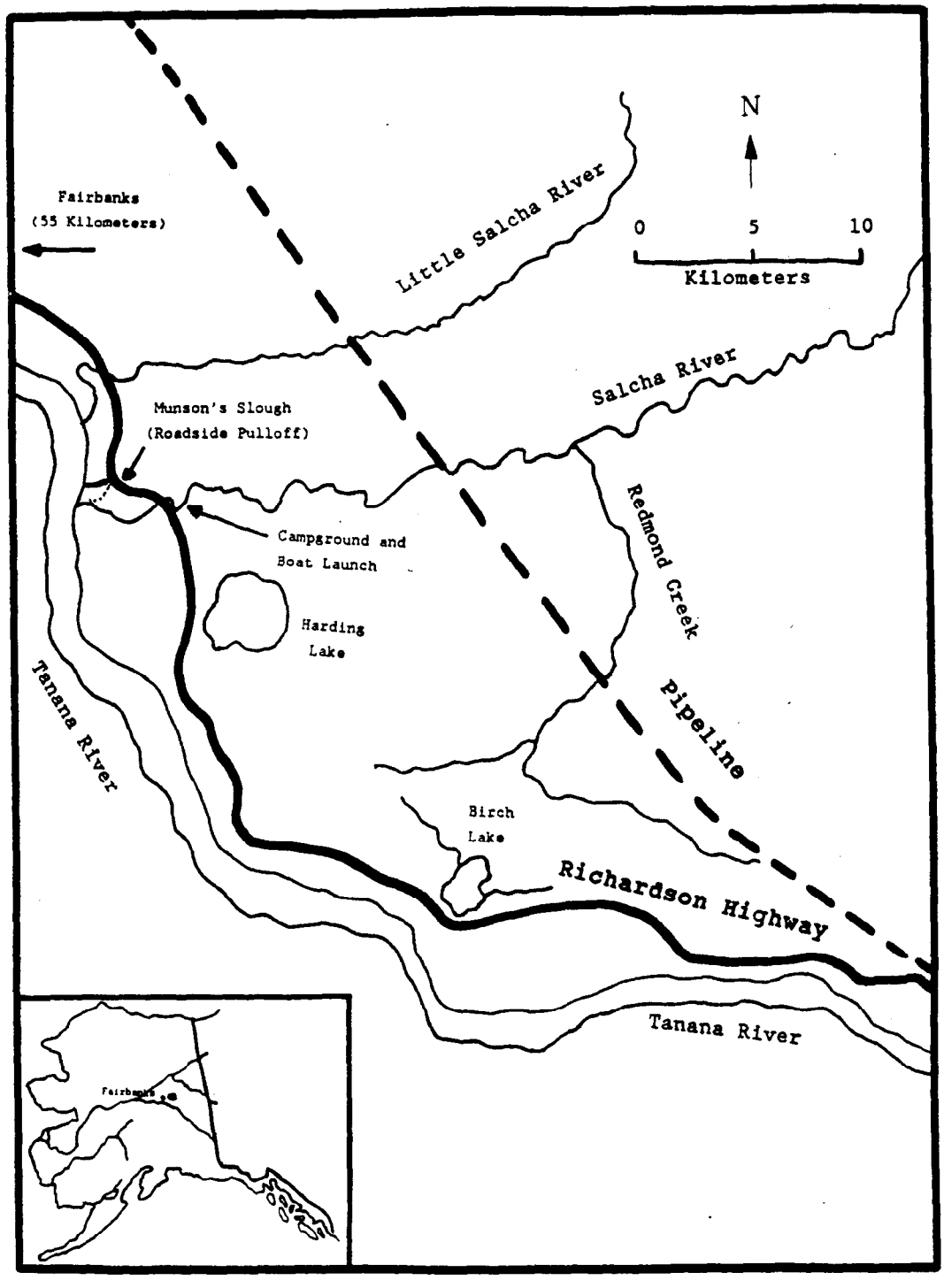

Figure 16. Map of the Salcha River, Tanana River drainage, Alaska.

and while not as important to recreational anglers, chum salmon provide additional angling opportunities. Annual sport harvest of chinook and chum salmon has been estimated by the statewide postal survey beginning in 1978 (Mills 1979-1988). Sport harvest estimates from creel surveys began in 1985. Up to 1987, fishing was allowed in the lower 23 km of the river. However, chinook salmon were found to be spawning in part of this section. Because of this, fishing was limited in 1988 to the lower 8 km of the river.

Specific objectives of the Salcha River creel survey in 1989 were to:

1) estimate angler-effort, CPUE, HPUE, catch and harvest expended at the Salcha River chinook and chum salmon fishery;

2) estimate the percent composition of angler demographics for the Salcha River that include: a) male/female, b) adult/youth, c) resident/non-resident/military, d) local/non-local, e) tourist/other, and f) terminal fishing gear (spinner/bait/flies/jigs/trolling/spear/bow and arrow);

3) estimate the percent response (opinions) to questions asked anglers at the Salcha River; and,

4) estimate the rating by anglers of the quality of fishing.

Methods

Two major access areas are available to Salcha River chinook and chum salmon anglers (Figure 16). All anglers using boats launch at the State boat launch facility where the Richardson Highway crosses the Salcha River. Most shore based anglers walk to the river from a parking area at the Richardson Highway pulloff located 1.5 km west of the river at Munson's Slough. Areas were combined into one survey. The creel survey was a roving harvest survey conducted during July, which is the time most chinook and chum salmon arrive in the fishery. Sampling during July was stratified into (1) weekends and (2) weekdays. The fishing day was defined to occur from 0600 to 2400 hours.

Sampling effort was optimally allocated based on catch and effort - as fishing effort increased during the peak of the run, so did sampling effort. The sampling effort was equally divided between weekends and weekdays. A total of 40 sample periods was desired. A sample period consisted of three consecutive hours; a count was conducted during each hour. The start time of the count was randomly chosen within the hour, and the start time of the period was randomly chosen within the defined fishing day. Total desired counts were 120 (40 periods x three hours). Twenty periods were allocated to weekends and 20 to weekdays, grouped around the peak of the runs.

The sampling procedure started with the creel clerk launching a boat and counting anglers between the access point (boat launch facility) and the mouth of the Salcha River. Angler counts took about 15 minutes to conduct. Interviews are performed during the remainder of the hour. Creel clerk time was split between the boat launch area and the shore angler's pulloff area.

A roving-type creel survey (Neuhold and Lu 1957) was used to obtain angler, effort, catch, and harvest for the lower Chena River chinook salmon fishery. The fishery was sampled using a stratified multi-stage sample survey. Strata were defined as follows:

1. 7-21 July, weekdays;
2. 7-21 July, weekends;
3. 22-30 July, weekdays; and,
4. 22-30 July, weekends.

Within each stratum days were sampled at random and represented the first stage of sampling. Within each sampled day, sample periods were selected at random from the available hours in each sampling day. Sampling periods were six hours in duration. In general only one sample period per day within a stratum was selected for surveying. Accordingly, although the sample period truly represented the second stage of sampling, it was not treated as such (since the among sampling period component of variance could not be consistently estimated). Within each stratum, on each selected day, the anglers interviewed represented the second sampling stage for catch and harvest rate calculations. Six angler counts were conducted during each sampled period. The counts conducted within each stratum on each selected day were treated as the second sampling stage for angler effort estimation.

A review of the data collected during 1989 indicated that during some sampling periods no anglers were interviewed, however anglers were fishing (i.e., count greater than zero). Accordingly, the approach used to obtain catch and harvest estimates was to obtain stratum estimates of angler effort, catch and harvest rates, i.e., CPUE and HPUE; and then to multiply the CPUE and HPUE stratum estimates by the stratum angler effort estimates to obtain the catch and harvest stratum estimates, respectively.

Completed-trip angler interviews were used to estimate the catch and harvest rates for expansion purposes since adequate numbers of completed trip interviews were obtained.

The CPUE and HPUE estimates were obtained by the jackknife estimation approach (Efron 1982). The jackknife approach for estimating CPUE and HPUE was used since most other estimators are known to be biased (for use as ratio estimators, i.e., for expansion), and the jackknife estimate has been shown to be less biased and procedures exist for correcting this bias (see Cochran 1977, section 6.15, pages 174-177; and Smith 1980). Prior to applying the jackknife procedure each angler's catch and harvest was weighted by the relative numbers of anglers utilizing the fishery during the interview period (as measured from the angler count). This weighting procedure ensures that each sample period's interview information is proportional to the angler effort at the time of the sample.

To obtain the estimates of the catch, harvest, and angler effort the procedures outlined in Chapter 2, using equations 35-56, were followed:

The assumptions necessary for unbiased point and variance estimates obtained by the procedures outlined in Chapter 2, equations 35-56 are:

1. no significant fishing effort occurred during the hours not surveyed (i.e., between 2400 and 0600 each day);

2. catch and harvest were independent of duration of fishing trip (as per DiConstanzo 1956);

3. the angler count process was approximately instantaneous, or we assume that the creel clerk traveled substantially faster than anglers move about the fishery, or exit, or enter; and,

4. there is small within day variance and the variance estimate is a minimum.

CPUE and HPUE of anglers participating in the 1989 lower Chena River chinook salmon fishery were estimated by the procedures outlined in Chapter 2, equations 57-72.

Results and Discussion

The Salcha River creel survey was conducted from 7 July through 30 July 1989. Too few chum salmon were sampled in the creel survey to estimate parameters of the chum salmon sport fishery on the Salcha River. All estimates presented below pertain to the chinook salmon sport fishery. There were 32 sample periods (or 16 sample days), eight less than desired (Table 34). Sample periods were less than expected because of run timing characteristics of chinook salmon. Arrival of chinook salmon in the fishery was about 10 days later, and more closely aggregated around the peak, thus shortening available sampling time. Forty-four percent of the sampling effort occurred during the peak of the run (22-30 July). A total of nine days were sampled on weekdays and seven days were sampled on weekends. The number of anglers counted on both weekends and weekdays tended to increase as the fishing day progressed, with peak counts occurring around 2000 hours (Figure 17). This is similar to the pattern observed for the lower Chena River chinook salmon fishery. Because angler counts increased throughout the day, the assumption of small within day variation was violated. In the future, this survey should be stratified by time of day to avoid biases associated with within day variability in anglers fishing.

A total of 176 anglers were interviewed, of which 52 (30%) interviews occurred during the peak of the run. Seventy-nine interviews (45%) were conducted on weekends (Table 34).

The highest mean angler count was 21.67 (SE = 4.31) and occurred in the weekend stratum prior to the peak of the run (Table 34). This is similar to that observed for the chinook salmon fishery in the lower Chena River.

Total angler effort was 5,606 hours (SE = 620; Table 34). This is about 668 hours more effort expended on the Salcha River than observed for the lower Chena River. Total catch was estimated to be 179 (SE = 63) chinook salmon. Total harvest was estimated at 123 (SE = 43) chinook salmon, with all the harvest occurring prior to the peak of the run. Harvest of chinook salmon in the Salcha River was 18% of that estimated for the lower Chena River. In both

Table 34. Angler catch and effort estimates for the Salcha River chinook salmon creel survey during the 7-30 July 1989 period.

Strata		Sampling Information[a]					Parameter Estimates[b]							
Temporal Component	Type of fishing day	dc	D	H	di	m	$\bar{\bar{x}}$	SE($\bar{\bar{x}}$)	$\hat{E}$	SE($\hat{E}$)	$\hat{C}$	SE($\hat{C}$)	$\hat{H}$	SE($\hat{H}$)
7-21 July	Weekend-holiday	3	4	18	3	40	21.67	4.31	1,560	311	118	55	88	37
	Weekday	6	11	18	6	84	13.53	2.68	2,679	530	34	23	34	23
	All days	9	15	---	9	124	---	---	4,239	615	152	59	123	43
22-30 July	Weekend-holiday	4	4	18	4	39	13.08	0.93	942	67	27	21	0	0
	Weekday	3	5	18	3	13	4.72	0.47	425	42	0	0	0	0
	All days	7	9	---	7	52	---	---	1,367	79	27	21	0	0
7-30 July	All days	16	24	---	16	176	---	---	5,606	620	179	63	123	43

[a] dc = number of days sampled for angler counts (all days sampled)
D = total number of days available for sampling
H = hours available for sampling within each day
di = number of days sampled for angler interviews (all days sampled minus sampled days in which no anglers interviewed)
m = total number of anglers interviewed.

[b] $\bar{\bar{x}}$ = mean of means-angler count (mean within day and then between day)
SE($\bar{\bar{x}}$) = standard error of $\bar{\bar{x}}$
$\hat{E}$ = estimated angler effort in angler-hours
SE($\hat{E}$) = standard error of $\hat{E}$
$\hat{C}$ = estimated catch of chinook salmon
SE($\hat{C}$) = standard error of $\hat{C}$
$\hat{H}$ = estimated harvest of chinook salmon
SE($\hat{H}$) = standard error of $\hat{H}$.

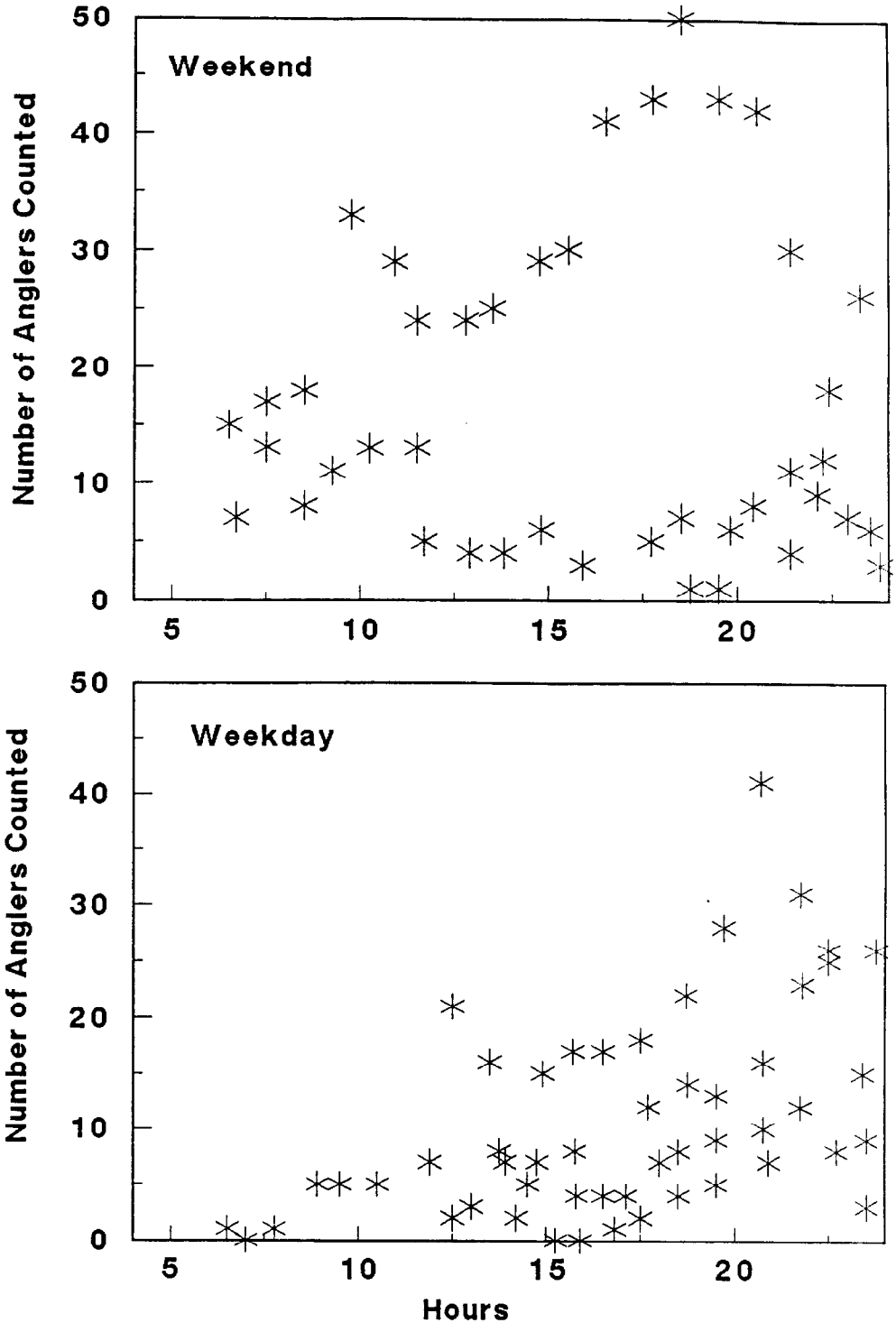

Figure 17. Distribution of angler counts by hour among strata, Salcha River, 1989.

chinook salmon fisheries, angler effort and harvest occurred prior to peak spawning activities of the fish populations.

Mean CPUE for the chinook salmon fishery was 0.03 (SE = 0.01). Mean HPUE was estimated at 0.02 (SE = 0.01; Table 35). CPUE and HPUE for the Salcha River fishery were one seventh the CPUE and HPUE for the lower Chena River chinook salmon fishery (see Table 20).

Total trips were estimated at 2,095 for the Salcha River fishery (Table 35).

The catch and harvest of chinook salmon in the Salcha River in 1989 was about an order of magnitude greater than in 1988 (19 and 19, respectively; Baker 1989). The catch and harvest of chinook salmon in the Salcha River has been traditionally less than the catch and harvest of chinook salmon in the lower Chena River. This was the case in 1989. The estimated harvest of 123 chinook salmon is below the sport harvest guideline range of 300 to 700 chinook salmon imposed by the Board of Fisheries in 1987.

The majority of anglers interviewed at the Salcha River were shore anglers (81%), male (90%), adult (89%), and residents of the State of Alaska (48%) (Table 36). Forty-one percent of the anglers were military personnel and 11% were non-residents. Of the anglers who were military or residents, 87% were from the Fairbanks-North Pole area. Only 8% of all the anglers interviewed were tourists. The proportion of non-local and tourist anglers in 1989 was slightly greater (13% and 7%, respectively) than that observed in 1988. Most anglers (99%) used spinners as their terminal gear type.

Anglers gave the fishery a median rating of 3.00, which is fair (Table 37). Eighty-three percent of these anglers knew the bag limit for salmon. The majority (66%) of anglers had no opinion regarding public boat access at the Salcha River. The majority of anglers approved of reduced seasons and fishing closures as a means of managing the fishery (82%). Most (93%) approved of stocking chinook salmon in the Salcha River. Angler attitudes in 1989 differed from those in 1988 in regards to public boat access and management of the fishery through reduced seasons and closures. In 1988, 100% of those interviewed felt that access was adequate; and 97% approved of management with reduced seasons and closures (Baker 1989).

CHAPTER 7 - HARDING LAKE ARCTIC CHAR FISHERY

Introduction

Harding lake is located within 48 km of Fairbanks (Figure 18) and contains northern pike, rainbow trout, Arctic grayling, burbot, lake trout, sheefish and kokanee. In spite of its close location to a large population center in interior Alaska and diversity of fish species, Harding Lake has not produced a significant sport fishery. A new program to stock Harding lake with Arctic char began in 1988 and continued in 1989. This program is designed to increase the popularity of sport fishing in Harding Lake.

Table 35. Angler CPUE and HPUE estimates for the Salcha River chinook salmon creel survey during the 7-30 July 1989 period.

Strata		Sampling Information[a]			Parameter Estimates[b]				
		d	D	m	CPUE	SE(CPUE)	HPUE	SE(HPUE)	$\hat{A}$
7-21 July	Weekend-holiday	3	4	40	0.09	0.05	0.07	0.04	409
	Weekday	6	11	84	0.00	0.00	0.00	0.00	1,113
	All days	---	---	124	0.03	0.01	0.02	0.01	1,522
22-30 July	Weekend-holiday	4	4	39	0.05	0.04	0.00	0.00	307
	Weekday	3	5	13	0.00	0.00	0.00	0.00	266
	All days	---	---	52	0.03	0.02	0.00	0.00	573
7-30 July	All days			176	0.03	0.01	0.02	0.01	2,095

[a] d = number of days sampled for angler interviews
D = total number of days available for sampling
m = total number of anglers interviewed.

[b] CPUE = estimated catch per unit effort
SE(CPUE) = standard error of CPUE
HPUE = estimated harvest per unit effort
SE(HPUE) = standard error of HPUE.
$\hat{A}$ = estimated fishing trips.

Table 36. Demographic profile of anglers interviewed at the Salcha River, Tanana River drainage, Alaska, 1989.

Angler Characteristic	n[a]	%	SE (%)	Angler Characteristic	n[a]	%	SE(%)
Total Number of Interviews[b]	205	--	--	Local[c]	175	87	2
				Non-local	26	13	2
Shore Anglers	161	81	3	Guided	0	0	--
Boat Anglers	39	19	3	Unguided	205	100	--
Male	180	90	2	Tourist	17	8	2
Female	21	10	2	Other	188	92	2
Adult	177	89	2	Gear Type:			
Youth	23	11	2	Spinners	178	99	1
				Jigs	0	0	--
Resident	96	48	4	Flies	2	1	--
Non-Resident	22	11	2				
Military	83	41	3				

[a] Number of anglers in the categories will not always equal the total number of interviews because angler demographics were not marked down for all the anglers interviewed.

[b] Includes both complete- and incomplete-trip angler interviews combined.

[c] Local and non-local category includes Alaska residents only. Local category are anglers from the Fairbanks area.

Table 37. Opinions of anglers interviewed at the Salcha River, Tanana River drainage, Alaska, 1989.

Question	Opinion	n	%[a]	SE (%)
1. How would you rate the quality of fishing for chinook salmon in the Salcha River this year?	Excellent (1)	4	3	1
	Good (2)	42	31	4
	Fair (3)	40	30	4
	Poor (4)	49	36	4
	Total	135	100	
	Mean Rating =	2.99		
	Median Rating =	3.00		
2. What is the bag limit for chinook salmon in the Salcha River?	One	128	83	3
	Three	4	3	1
	Other	22	14	3
	Total	154	100	
3. Is public boat access adequate for the Salcha River?	Yes	44	28	4
	No	8	6	2
	No-Opinion	103	66	4
	Total	155	100	
4. What is your opinion of using reduced seasons and emergency closures to manage chinook salmon in the Salcha River?	Approve	134	82	3
	Disapprove	25	15	3
	No-Opinion	5	3	1
	Total	164	100	
5. What is your opinion of stocking chinook salmon in the Salcha River?	Approve	160	93	2
	Disapprove	0	0	--
	No-Opinion	6	7	2
	Total	166	100	

[a] Percentages are calculated for anglers with opinions only and do not take into account anglers in the no-opinion category.

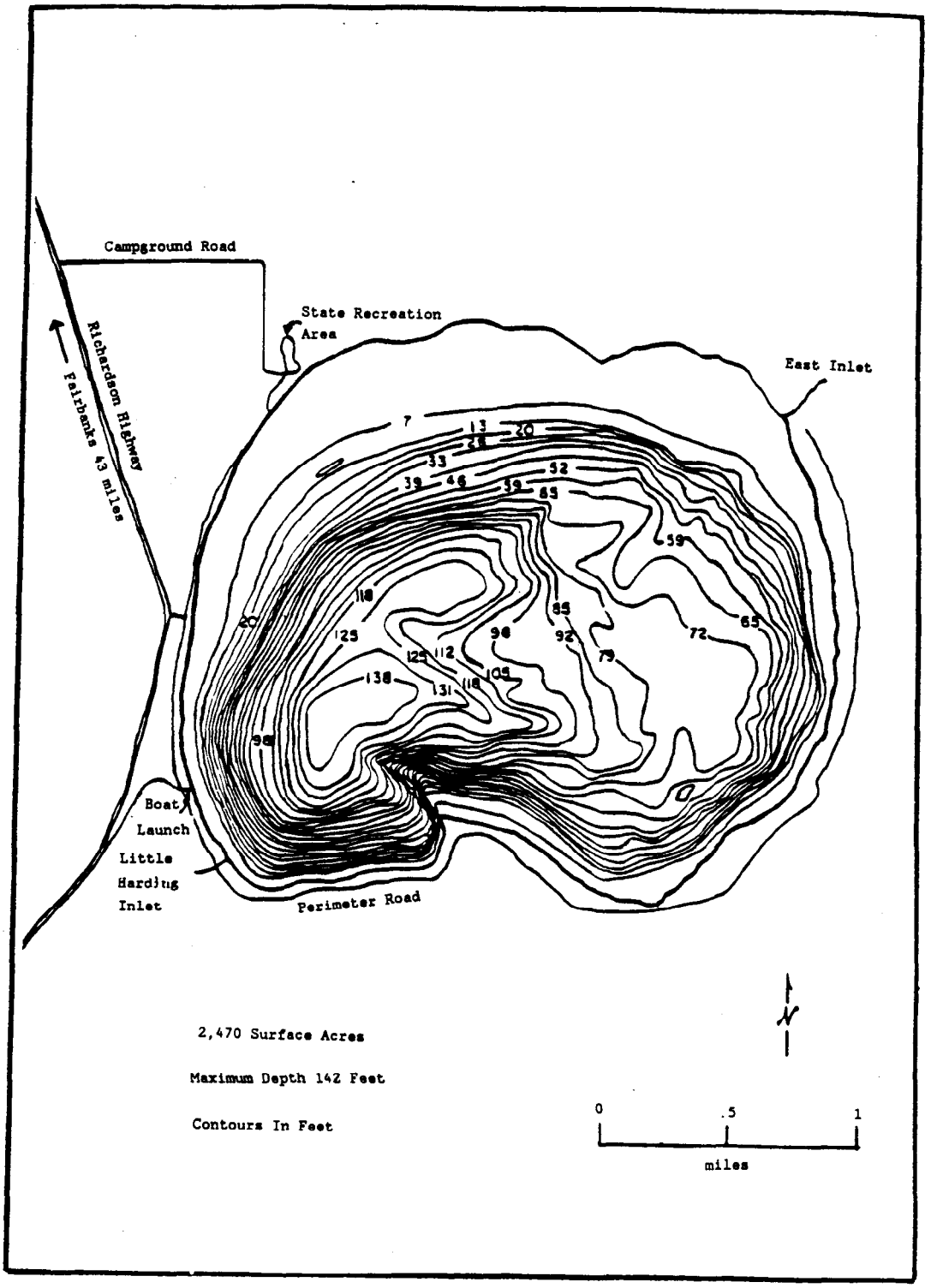

Figure 18. Map of Harding Lake, Tanana River drainage, Alaska.

In 1988, 30,800 Arctic char weighing 52 g (one third were marked with adipose fin clips) were stocked in Harding Lake. Four size groups were stocked in 1989: 12,600 weighing 20 g (unmarked); 8,400 weighing 122 g (all marked with right pelvic fin clips); 38,500 weighing 108 g (unmarked); and, 1,900 weighing 740 g (all tagged). The goal of this study was to determine the size group contributing the greatest proportion to the fishery. This information will be used to ascertain the cost-effectiveness of stocking each size group in Harding Lake.

In addition to obtaining information on Arctic char, the creel survey gathered data on other species of fish targeted and harvested by anglers. No specific objective criteria were associated with fish species other than Arctic char.

Specific objectives of this creel survey were to:

1. estimate angler-effort, CPUE, HPUE, catch and harvest for the Harding Lake Arctic char fishery;

2. provide estimates of percent age composition, percent Relative Stock Density, and mean fork length-at-age (mm) for Arctic char in the harvest sample at Harding Lake;

3. estimate the percent composition of angler demographics for the Harding Lake Arctic char fishery that include: a) male/female, b) adult/youth, c) resident/non-resident/military, d) local/non-local, e) tourist/other, and f) terminal fishing gear (spinners/flies/jigs/bait);

4. estimate the percent response to questions asked anglers; and,

5. estimate the rating by anglers of the quality of fishing.

This report will also address an objective outlined in the federal contract F-10-5, Job T-8-1, which is to estimate the relative contribution of Arctic char caught in the sport fishery at Harding Lake that were stocked in 1988 and 1989 at different times and sizes.

Two creel surveys were conducted at Harding Lake: summer and winter.

Methods

In the summer, a roving harvest survey was conducted for weekdays and weekends. In the winter a roving harvest survey was conducted on just weekends, when the majority of ice-fishing was thought to occur.

Summer:

There is one major access point at a state campground (Figure 18). Private cabins are also situated around the lake. In the summer the creel clerk divided sampling effort between interviewing anglers at the campground dock and using a boat to interview and count anglers on the lake. Most sample periods were four hours. The clerk interviewed anglers at the dock for one

hour and during the next hour was on the lake counting and interviewing anglers. This was repeated a second time. Counts started at randomly-selected hours within the period.

The creel survey in the summer was a roving-type survey (Neuhold and Lu 1957) and was used to obtain angler effort, catch and harvest. The fishery was sampled using a stratified multi-stage survey, with three month strata (June, July, August) and three time strata (weekdays, 0800 to 1600 hours; weekdays 1600 to 220 hours; and weekends 0800 to 2200 hours).

Within each stratum, days were sampled at random and represented the first stage of sampling. Within each sampled day, sample periods were selected at random from the available hours in each sampling day. In general only one sample period per day within a stratum was selected for surveying. Accordingly, although the sample period represented the second stage of sampling, it was not treated as such (since the among sampling period component of variance could not be consistently estimated). Within each stratum, on each selected day, the anglers interviewed represented the second sampling stage for catch and harvest rate calculations. Two angler counts were conducted during each sampled four hour period. Counts were conducted concurrently during the angler interview process as the fishery was roved by the creel clerk. The counts conducted within each stratum on each selected day were treated as the second sampling stage for angler effort estimation.

The angling day was a possible 14 hours. Sampling effort was proportionally allocated based on the amount of time in each time strata. Thus, sampling effort was allocated 38% to weekdays 0800 to 1600 hours; 29% to weekdays 1600 to 2200 hours; and 33% to weekends.

Both complete-trip and incompleted-trip angler interviews were used to estimate the catch and harvest rates for expansion purposes.

The CPUE and HPUE estimates were obtained by the jackknife estimation approach (Efron 1982). The jackknife approach for estimating CPUE and HPUE was used since most other estimators are known to be biased (for use as ratio estimators, i.e., for expansion), and the jackknife estimate has been shown to be less biased and procedures exist for correcting this bias. (see Cochran 1977, section 6.15, pages 174-177; and Smith 1980). Prior to applying the jackknife procedure each angler's catch and harvest was weighted by the relative numbers of anglers utilizing the fishery during the interview period (as measured from the angler count). This weighting procedure ensured that each sample period's interview information was proportional to the angler effort at the time of the sample.

To obtain the estimates of the catch, harvest, and angler effort the procedures as outlined in chapter 2, equations 35-56 were followed.

The assumptions necessary for unbiased point and variance estimates obtained by the procedures outlined in Chapter 2, equations 35-56, are:

1. incomplete-trip angler catch and harvest rates, though probably biased, were assumed to provide an approximate estimate of complete-trip angler catch and harvest rates;

2. no significant fishing effort occurred during the hours not surveyed;

3. catch and harvest were independent of duration of fishing trip (as per DiConstanzo 1956);

4. the angler count process was approximately instantaneous, or we assume that the creel clerk traveled substantially faster than anglers move about the fishery, or exit, or enter; and,

5. the among sampling period component of variation for catch and harvest rate was small in comparison to the among angler component and the among day component.

The last assumption, above, was necessary due to the inability to estimate the among sample period variance component (within each sampled day and stratum). Regardless of the validity of assumption number 5, the variance estimates were biased negatively by an unknown amount (too small). The point estimates should be unbiased and unaffected by the validity of assumption 5.

However, assumption number 4 is undoubtedly invalid, in that the counts were conducted concurrently with interviews over a four hour period. During these count/interview samples some anglers entered the fishery and left the fishery (non-instantaineous count). The effect of the non-instantaneous count nature of the counts would be to bias the point estimates of angler effort, catch, and harvest in an upward manner, in that anglers with longer trip duration would have larger probability of being counted than anglers with short trip duration (Robson 1961). The degree of this bias is unknown.

Winter:

A roving-type creel survey (Neuhold and Lu 1957) was used to obtain angler, effort, catch, and harvest for the winter Harding Lake Arctic char fishery. The fishery was sampled using a stratified two-stage sample survey. The survey covered the weekend-only days from 23 December 1989 through 24 March 1990. Only days with air temperatures above approximately -34.4° C (-30° F) were sampled. It was assumed no angler effort, catch, or harvest occurred on these "too cold" days. Otherwise, strata were defined as the weekend-days for each month (i.e., December[13], January, February, and March).

The angling and sampling day was defined as the hours from 1000 to 1600, or six hours long.

Within each stratum every day (excepting the "too cold" days) was sampled and represented the first stage of sampling. Within each sampled day, three

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[13] Starting on 23 December.

systematic angler counts were conducted. Each count took approximately two hours to conduct. Accordingly, an angler count was taken every two hours (i.e., starting at 1000, 1200, and 1400). The counts within each day represented the second stage of sampling for the angler effort estimation process.

During periods encountered in which counts were not conducted all anglers exiting the fishery and encountered during angler counts were interviewed. The anglers interviewed represented the second sampling stage for catch and harvest rate calculations.

The approach used to obtain catch and harvest estimates was to obtain stratum estimates of angler effort, catch and harvest rates, i.e., CPUE and (HPUE); and then to multiply the CPUE and HPUE stratum estimates by the stratum angler effort estimates to obtain the catch and harvest stratum estimates, respectively.

Both completed-trip and incompleted-trip angler interviews were used to estimate the catch and harvest rates for expansion purposes due to the low total number of interviews.

The CPUE and HPUE estimates were obtained by the jackknife estimation approach (Efron 1982). The jackknife approach for estimating CPUE and HPUE was used since most other estimators are known to be biased (for use as ratio estimators, i.e., for expansion), and the jackknife estimate has been shown to be less biased and procedures exist for correcting this bias (see Cochran 1977, section 6.15, pages 174-177; and Smith 1980). Prior to applying the jackknife procedure each angler's catch and harvest was weighted by the relative numbers of anglers utilizing the fishery during the interview period (as measured from the angler count). This weighting procedure ensured that each sample period's interview information was proportional to the angler effort at the time of the sample.

To obtain the estimates of the catch, harvest, and angler effort the procedures as outlined in Chapter 2, equations 35-56 were followed.

CPUE and HPUE of anglers participating in the 1989 Harding Lake winter Arctic char fishery were estimated by the procedures outlined in Chapter 2, equations 57-72.

The assumptions necessary for unbiased point and variance estimates obtained by the procedures outlined above are:

1. incompleted-trip angler catch and harvest rates, though probably biased, were assumed to provide an approximate estimate of completed-trip angler catch and harvest rates;

2. no significant fishing effort occurred during the hours not surveyed (i.e., between 1600 and 1000 each day);

3. catch and harvest were independent of duration of fishing trip (as per DiConstanzo 1956); and,

4. the angler count process was approximately instantaneous, or we assume that the creel clerk traveled substantially faster than anglers move about the fishery, or exit, or enter.

Relative contribution of Arctic char caught in the sport fishery was tested with chi-square analysis.

Results and Discussion

No Arctic char were reported harvested in the summer creel survey, although sufficient number of northern pike were sampled to obtain estimates of angler effort, catch and harvest. Arctic char were taken through the ice by anglers in winter.

Summer:

The Harding Lake Arctic char summer creel survey began on 2 June and continued through 24 August 1989. A total of 41 days were sampled (Table 38). Due to a lack of observed fishing effort at Harding Lake in August, the creel survey was attenuated for that month. Accordingly, all time strata were combined into one during the month of August for purposes of analysis.

A total of 140 interviews were conducted, of which 49% were in June and 44% were in July (Table 38). The highest mean angler counts were 7.80 (SE = 2.23), and 7.10 (SE = 1.78) and occurred within the weekend strata in June and July, respectively (Table 38).

Total angler effort was estimated at 6,249 hours (SE = 952). The greatest angler effort occurred on weekends in July (2,746, SE = 785) and in June (2,286, SE = 366; Table 38).

Total catch of northern pike was estimated to be 1,237 (SE = 453). Total harvested was estimated at 665 (SE = 316) northern pike, with the majority of the harvest (364 northern pike) taken during weekends in July. A substantial portion of the northern pike fishery at Harding Lake can be characterized as catch-and-release, since about half the northern pike caught were released by anglers. The catch of small northern pike may account for some of the releases.

Table 38. Angler catch and effort estimates for the Harding Lake northern pike creel survey during the 2 June - 24 August 1989 period.

Strata		Sampling Information[a]					Parameter Estimates[b]							
Month	Type/time of day	dc	D	H	di	m	$\bar{x}$	SE($\bar{x}$)	$\hat{E}$	SE($\hat{E}$)	$\hat{C}$	SE($\hat{C}$)	$\hat{H}$	SE($\hat{H}$)
June	Weekdays/0800-1600	8	22	8	5	13	3.12	0.94	550	166	102	75	0	0
	Weekdays/1600-2200	5	22	8	5	25	4.70	1.32	827	233	136	102	136	102
	Weekends/0800-2200	5	8	16	4	31	7.10	1.78	909	228	25	25	0	0
	All days/time periods	---	---	---	---	69	---	---	2,286	366	262	129	136	102
July	Weekdays/0800-1600	6	20	8	2	11	2.17	1.02	347	164	298	291	0	0
	Weekdays/1600-2200	5	20	8	4	11	1.90	0.80	304	128	0	0	0	0
	Weekends/0800-2200	5	22	16	5	40	7.80	2.23	2,746	785	450	261	364	246
	All days/time periods	---	---	---	---	62	---	---	3,396	812	748	391	364	246
August	All days/time periods	7	31	16	4	9	1.14	0.68	567	338	227	190	165	170
All months	All days/time periods	---	---	---	---	140	---	---	6,249	952	1,237	453	665	316

[a] dc = number of days sampled for angler counts (all days sampled)
D = total number of days available for sampling
H = hours available for sampling within each day
di = number of days sampled for angler interviews (all days sampled minus sampled days in which no anglers interviewed)
m = total number of anglers interviewed.

[b] $\bar{x}$ = mean of means-angler count (mean within day and then between day)
SE($\bar{x}$) = standard error of $\bar{x}$
$\hat{E}$ = estimated angler effort in angler-hours
SE($\hat{E}$) = standard error of $\hat{E}$
$\hat{C}$ = estimated catch of northern pike
SE($\hat{C}$) = standard error of $\hat{C}$
$\hat{H}$ = estimated harvest of northern pike
SE($\hat{H}$) = standard error of $\hat{H}$.

Age and length data were collected from five northern pike examined in the harvest. The results were as follows:

Sex	Age	Length (mm)
unknown	2	302
male	3	349
male	4	414
female	5	641
unknown	10	545
Mean	4.8	450.2
SE =	1.25	56.18

The majority of anglers interviewed were male (88%), adult (92%), and local residents (73%; Table 39). Tourists comprised 18% of the anglers interviewed. The majority (97%) of anglers used spinners for terminal gear (Table 39).

The majority (54%) of anglers interviewed in 1989 were fishing Harding Lake for the first time (Table 40). Twenty-seven percent said they fished at Harding Lake once or twice a year. Northern pike anglers gave the Harding Lake fishery a median rating of good. However, the majority (53%) gave no opinion when asked this question, probably because they were fishing Harding Lake for the first time. The median rating of good is surprising and may be due in part to the fact that Harding Lake is one of the few road-accessible fisheries for northern pike in the Tanana drainage. Seventy-one percent of anglers interviewed approved of stocking Arctic char in Harding Lake. (Table 40).

Of those anglers voicing an opinion regarding the species they normally target at Harding Lake, 78% (63 anglers) said they target northern pike. Sixteen anglers interviewed were fishing specifically for burbot. One angler was fishing for rainbow trout. No anglers interviewed in the summer creel survey targeted Arctic char, lake trout or Arctic grayling (Table 40). When asked what species the angler would prefer to catch at Harding Lake, 41% responded that they would prefer to fish for northern pike, 25% said they would prefer to catch lake trout, 14% said Arctic char would be their targeted species, 6% wanted to fish for rainbow trout, and only 3% wanted to catch burbot (Table 40). Eighty-three percent said they were unsuccessful in catching their target species at Harding Lake in 1989. To create a targeted Arctic char fishery at Harding Lake, greater efforts must be expended by ADFG to publicize the stocking and availability of Arctic char in Harding Lake.

Winter:

The Harding Lake Arctic char winter creel survey began on 23 December, 1989 and continued through 25 March 1990. A total of 22 days were sampled (Table 41), and a total of 85 interviews were conducted, of which 2% were in December, 53% in January, 7% in February and 38% in March. The highest mean

Table 39. Demographic profile of anglers interviewed at Harding Lake, Tanana River drainage, Alaska, 1989.

Angler Characteristic	n[a]	%	SE (%)	Angler Characteristic	n[a]	%	SE (%)
Total Number of Interviews[b]	180	--	--	Local[c]	129	73	3
				Non-local	47	27	3
Male	158	88	6	Tourist	--	18	3
Female	21	12	6	Other	147	82	3
Adult	164	92	4	Gear Type:			
Youth	14	8	4	Spinners	163	97	2
				Flies	4	2	1
Resident	100	53	13	Jigs	1	1	<1
Non-Resident	41	22	9	Bait	0	0	--
Military	49	26	10				

[a] Number of anglers in the categories will not always equal the total number of interviews because angler demographics were not marked down for all the anglers interviewed.

[b] Includes both complete- and incomplete-trip angler interviews combined.

[c] Local and non-local category includes Alaska residents only. Local category are anglers from the Fairbanks-North Pole area.

Table 40. Opinions of anglers interviewed at Harding Lake, Tanana River

Question	Opinion	n	%[a]	SE(%)
1. How often do you fish here?	First Time	93	54	14
	1-2 times/year	48	27	11
	1-2 times/month	25	14	7
	1-2 times/week	7	4	2
	> 2 times/week	2	1	1
	Total	175	100	
2. How would you rate the quality of fishing at Harding Lake this year?	Excellent (1)	0	0	--
	Good (2)	21	12	6
	Fair (3)	40	23	10
	Poor (4)	22	12	6
	No Opinion (5)	94	53	14
	Total	177	100	
	Mean Rating	3.0		
	Median Rating	2		
3. What is your opinion of stocking Arctic char in Harding Lake?	Approve	124	71	12
	Disapprove	1	1	<1
	No Opinion	49	28	12
	Total	174	100	
4. What species do you normally catch at Harding Lake?	Grayling	0	0	--
	Pike	63	36	14
	Rainbow Trout	1	1	<1
	Lake Trout	0	0	--
	Arctic Char	0	0	--
	Burbot	16	9	5
	Other	1	1	<1
	No Opinion	92	53	15
	Total	173	100	

- continued -

Table 40. (page 2 of 2)

Question	Opinion	n	%[a]	SE(%)
5. What species do you prefer to catch at Harding Lake?	Grayling	0	0	--
	Pike	72	40	14
	Rainbow Trout	10	6	3
	Lake Trout	43	25	11
	Arctic Char	24	14	7
	Burbot	5	3	2
	Other	1	1	<1
	No Opinion	20	11	6
	Total	175	100	
6. How successful have you been at catching your targeted species this year?	Zero	143	82	8
	1 - 10	29	17	8
	11 - 20	1	1	<1
	>20	0	0	--
	Total	435	100	

[a] Percentages are calculated for anglers with opinions only and do not take into account anglers in the no-opinion category.

angler counts were 3.72 (SE = 0.72) and 2.00 (SE = 0.36) and occurred in January and March, respectively.

Total angler effort was estimated at 246 hours (SE = 31.9; Table 41). The greatest angler effort occurred in January (134, SE = 25.8) and in March (96, SE = 17.5)

Estimated harvest of Arctic char during the Harding Lake winter creel survey was 49 (SE = 16; Table 41). The greatest portion of the harvest, 82% or 40 fish (SE = 14), occurred in the month of January. Although 40% of the angler effort occurred in March, there was no harvest of Arctic char. In addition to the estimated harvest of 49 Arctic char during the weekend creel survey, 146 Arctic char were reported harvested[14] prior to the initiation of the creel survey in late December. Harvest outside the survey was documented through telephone conversations with anglers, and by ADFG staff fishing during personal time.

Mean CPUE for the Harding Lake winter survey was 0.29 (SE = 0.11; Table 42), with the highest CPUE occurring during the month of February (0.75, SE = 0.63). Mean HPUE for the entire survey was 0.17 (SE = 0.05), with the greatest HPUE also occurring in February (0.75, SE = 0.63).

Total fishing trips was estimated at 98 for the Harding Lake fishery in winter (Table 42). Most (54) of the fishing trips occurred in January.

The majority (58%) of Arctic char sampled in the harvest were in the quality range (Table 43). Of 45 Arctic char examined, three were tagged (from the 1,900 Arctic char stocked at 740 g in 1989). These fish ranged from 371 mm to 401 mm in length. Six Arctic char examined had right pelvic fin clips (from the 8,400 Arctic char stocked at 122 g in 1989). These fish ranged from 195 mm to 308 mm in length. No char with adipose fin clips were observed in the winter harvest sample.

It was assumed that survival of the 30,800 Arctic char stocked in 1988 to December 1989 was 55%[15], for an estimated 16,940 available to the fishery in December 1989. Of the fish stocked in 1989, the small (< 20 g) group of 12,600 were judged too small to be available to the December 1989 fishery. The other groups stocked in 1989 were assumed to have a 75% survival rate from the time of stocking to December 1989. Based on assumed survival rates, expected numbers of each group (except unmarked fish) in the harvest sample were calculated (Table 44). Expected values for unmarked fish could not be calculated since unmarked fish were comprised of two separate stockings.

The observed number of fish (adipose clipped) stocked at 52 g in 1988 was significantly less (α = 0.05) than expected. The observed number of fish stocked at 122 g in 1989 was no different from that expected. The observed

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[14] Mike Doxey. 1989. Personal Communication. ADFG, Division of Sport Fish, 1300 College Road, Fairbanks, Ak 99701.

[15] Cal Skaugstad. 1989. Personal Communication. ADFG, Division of Sport Fish, 1300 College Road, Fairbanks, Ak 99701.

Table 41. Angler catch and effort estimates for the Harding Lake winter Arctic char survey[a] during the 23 December 1989 - 25 March 1990 period.

Strata	Sampling Information[b]					Parameter Estimates[c]							
Month	dc	D	H	di	m	$\bar{\bar{x}}$	SE($\bar{\bar{x}}$)	$\hat{E}$	SE($\hat{E}$)	$\hat{C}$	SE($\hat{C}$)	$\hat{H}$	SE($\hat{H}$)
December	2	2	6	1	2	0.33	0.29	4.0	3.5	0	0	0	0
January	6	6	6	6	45	3.72	0.72	134.0	25.8	64	26	40	14
February	6	6	6	2	6	0.33	0.17	12.0	6.0	9	8	9	8
March	8	8	6	7	32	2.00	0.36	96.0	17.5	0	0	0	0
All months	22	22	---	16	85	---	---	246.0	31.9	73	27	49	16

[a] Weekend only without cold days.

[b] dc = number of days sampled for angler counts (all days sampled)
D = total number of days available for sampling
H = hours available for sampling within each day
di = number of days sampled for angler interviews (all days sampled minus sampled days in which no anglers interviewed)
m = total number of anglers interviewed.

[c] $\bar{\bar{x}}$ = mean of means-angler count (mean within day and then between day)
SE($\bar{\bar{x}}$) = standard error of $\bar{\bar{x}}$
$\hat{E}$ = estimated angler effort in angler-hours
SE($\hat{E}$) = standard error of $\hat{E}$
$\hat{C}$ = estimated catch of Arctic char
SE($\hat{C}$) = standard error of $\hat{C}$
$\hat{H}$ = estimated harvest of Arctic char.
SE($\hat{H}$) = standard error of $\hat{H}$.

Table 42. Angler CPUE and HPUE estimates for the Harding Lake winter Arctic char creel survey[a] during the 23 December 1989 - 25 March 1990 period.

Strata	Sampling Information[b]			Parameter Estimates[c]				
Month	d	D	m	CPUE	SE(CPUE)	HPUE	SE(HPUE)	$\hat{A}$
December	1	2	2	0.00	0.00	0.00	0.00	1
January	6	6	45	0.50	0.21	0.28	0.08	54
February	2	6	6	0.75	0.63	0.75	0.63	2
March	7	8	32	0.00	0.00	0.00	0.00	41
All months	---	---	85	0.29	0.11	0.17	0.05	98

[a] Weekend only without cold days.

[b] d = number of days sampled for angler interviews
D = total number of days available for sampling
m = total number of anglers interviewed.

[c] CPUE = estimated catch per unit effort
SE(CPUE) = standard error of CPUE
HPUE = estimated harvest per unit effort
SE(HPUE) = standard error of HPUE.
$\hat{A}$ = estimated fishing trips.

Table 43. Relative Stock Density (RSD) of Arctic char in the winter survey of Harding Lake, Tanana River drainage, Alaska, 1989-1990.

Category	Range[a]	n	%	SE (%)
Arctic Char				
Stock	180 - 224	12	27	7
Quality	225 - 299	26	58	10
Preferred	300 - 374	4	9	4
Memorable	375 - 449	2	4	3
Trophy	450 +	1	2	2
Total		45	100	
Mean Length = 259				
SE = 11				

[a] Range is in fork length (mm) for rainbow trout, from interior Alaska which is judged most applicable to stocked Arctic char in lakes.

Table 44. Observed and expected samples of Arctic char in the winter harvest at Harding Lake from 1988 and 1989 stockings.

Stocking	Observed	Expected	Chi-square	df
1988 - adipose clip	0	4.59	4.59[a]	1
1989 - right pelvic clip	6	5.26	0.11	1
1989 - tagged	3	1.18	2.80[b]	1
Total	9	11.03	7.51	2

[a] Significant for $\alpha = 0.05$.

[b] Significant for $\alpha = 0.10$.

number of fish stocked at 739 g in 1989 was significantly greater ($\alpha = 0.10$) than expected (Table 44). These results indicate that the greatest return to the fishery will be fish stocked at a large (739 g) size.

Of 81 anglers interviewed during the winter creel survey, 93% were male, 81% were adults and 96% were local residents. Primary terminal gear used was bait (88%).

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